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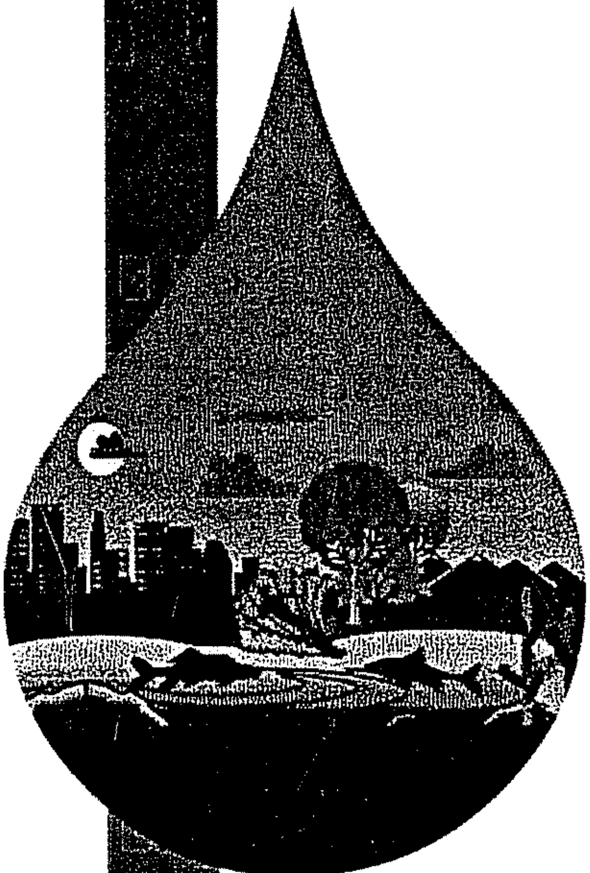
Description and Assessment of Operations, Maintenance, and Sensitive Species of the Lower Colorado River



August 1996

Final

Biological Assessment Prepared for

U.S. Fish and Wildlife Service and Lower Colorado River Multi-Species Conservation Program

by

U.S. Bureau of Reclamation, Lower Colorado Region

DESCRIPTION AND ASSESSMENT OF OPERATIONS, MAINTENANCE, AND SENSITIVE SPECIES OF THE LOWER COLORADO RIVER

BIOLOGICAL ASSESSMENT PREPARED FOR U.S. FISH AND WILDLIFE SERVICE AND LOWER COLORADO RIVER MULTI-SPECIES CONSERVATION PROGRAM

BY
U.S. BUREAU OF RECLAMATION,
LOWER COLORADO REGION

DATED
August 1996

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Submit comments or questions to comments@lc.usbr.gov

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I. OVERVIEW

A. Introduction

This biological assessment (BA) 1) describes the U.S. Bureau of Reclamation's (Reclamation) current and projected routine lower Colorado River operations and maintenance, 2) describes the environmental baseline, 3) discusses critical habitat and the biology and distribution of species along the lower Colorado River that have protected status, or may be subject to such status under the Endangered Species Act of 1973, as amended (ESA), and 4) determines the potential effect of such operations and maintenance on such species. The ESA section 7 consultation resulting from this BA focuses on those actions in which there is discretionary Federal (Reclamation) involvement or control.

The geographic area included in this BA is within the lower Colorado River basin (Figure 1) and is focused on the mainstream lower Colorado River and its 100-year flood plain, from the upper end of Lake Mead at Pierce Ferry to the Southerly International Boundary with Mexico (SIB) (Figure 2). The BA addresses Reclamation's discretionary operations of lower Colorado River dam facilities, maintenance of river control features, and other activities such as endangered species conservation.

In the United States, the Colorado River drains about 250,000 square miles from portions of seven States - Wyoming, Colorado, Utah, New Mexico, Nevada, Arizona, and California. Over 170,000 square miles of the watershed are above Hoover Dam. The headwaters of the Colorado River are located in central Colorado, about 1,440 river-miles upstream from its mouth and 1,000 river-miles upstream from Hoover Dam.

The upper Colorado River basin ranges from 3,000 to over 14,000 feet in elevation and supplies most of the water discharge which occurs in the entire basin. Most water discharge occurs during the months of April through July when the winter snowpack melts. The area of the lower Colorado River basin is generally arid, with very little tributary runoff reaching the mainstream of the Colorado River, except during occasional storms. Lee Ferry, 15.5 miles downstream of Glen Canyon Dam, is cited in the Colorado River Compact as the boundary between the upper basin and the lower basin of the Colorado River.

Management of Colorado River water resources is a complex undertaking involving physical, biological, socioeconomic, and legal considerations. Management of the river is governed by an international treaty with Mexico and several minutes of the International Boundary and Water Commission (IBWC), two major interstate compacts, a Decree of the U.S. Supreme Court, various statutes, and contracts between the United States and water and power customers. These collectively are known as the "Law of the River" (Table 1).

The Federal role in managing the lower Colorado River differs in many respects, sometimes significantly, from its role in the upper basin. In the lower basin of the Colorado River, Reclamation serves as custodian for the Secretary of the Interior (Secretary) in his role as the Watermaster. As Watermaster, the Secretary's three operational priorities are: 1) river regulation, improvement of navigation, and flood control, 2) irrigation and domestic uses, including the satisfaction of present perfected water rights, and 3) power.

B. Background

In discussions with the U.S. Fish and Wildlife Service (FWS) and non-Federal parties that have an interest in the use and management of resources associated with the lower Colorado River, Reclamation has agreed to develop this BA as an initial description of routine, ongoing river operations and ESA-protected resources. As an assessment of the potential effects of discretionary operations on ESA-protected resources, this document serves two purposes: 1) initial documentation for the ongoing ESA section 7 consultation between Reclamation and FWS, and 2) initial reference for development and implementation of a multi-species conservation program by river stakeholders. The first purpose addresses Reclamation's current discretionary operation and maintenance of the river, while the second purpose addresses non-Federal actions via an ESA section 10 permit application and future Federal actions via section 7 of ESA. The latter permits both non-Federal and Federal parties to participate together in the Lower Colorado River Multi-Species Conservation Program (MSCP). Sections 7 (Federal) and 10 (non-Federal) are separate processes under the ESA, yet they are anticipated to work concurrently toward natural resource conservation in the lower Colorado

River.

Since there is significant non-Federal interest in developing and implementing an MSCP that could significantly affect the survival and recovery of ESA-protected species, the Department of the Interior (DOI), which includes Reclamation and FWS, agreed to work with public and private interests in the lower basin States (Arizona, California, Nevada) to develop and implement such a multi-species conservation plan. This agreement was formalized via a memorandum of agreement with an effective start date of August 2, 1995, and, in July 1996, is being clarified through a memorandum of clarification. The agreement among Federal and non-Federal agencies to form a partnership with other interested parties for the purpose of developing the MSCP was announced via a DOI news release dated September 15, 1995. On June 26, 1996, DOI and the MSCP steering committee signed an agreement to equally cost share the development of the MSCP and implementation of interim conservation measures. A summary of the MSCP and copies of the referenced news release and Federal/non-Federal cost-sharing agreement are provided in Appendix A.

The MSCP planning effort was originally scheduled for completion on or about 1998. During the 3-year period (August 1995 -August 1998) for developing the MSCP, it is proposed that participating agencies, both Federal and non-Federal, will sponsor, fund, and implement interim conservation measures, at a minimum, designed to aid in the survival and recovery of the endangered razorback sucker and bonytail. Consequently, the immediate needs of some of the ESA-protected species will be addressed and, thus, will not have to wait until the MSCP is formulated and implemented. Actually, Reclamation is presently participating in significant efforts to assure the survival of the endangered razorback sucker and bonytail. These and other voluntary conservation measures under Section7(a)(1) of the ESA are discussed in Section II of this document.

C. Biological Assessment Content, Scope, and Public Process

1. Request for Formal Consultation

This BA serves as a written request, under the provisions of Title 50 Code of Federal Regulations (CFR) Part 402.14, to initiate formal consultation with FWS on Reclamation's discretionary routine operations and maintenance on the lower Colorado River from the full pool elevation of Lake Mead to the SIB. Under 50 CFR 402.12(j), a Federal agency may initiate formal consultation concurrently with the submission of a biological assessment to FWS. Reclamation is requesting formal consultation based on its "may affect," "may affect, but not likely to adversely affect," and "may adversely modify critical habitat" (50 CFR 402.14 and FWS 1994 Draft Endangered Species Consultation Handbook) determinations as discussed in Section IV of this document. Additionally, a conference with FWS is requested on the proposed listing of the flat-tailed horned lizard as threatened.

2. Content and Scope

"The contents of a biological assessment are at the discretion of the Federal agency and will depend on the nature of the Federal action" [50 CFR 402.12 (f)]. However, under 50 CFR 402.14(c), the request for formal consultation shall include information in six (a-f) basic areas:

a. Action: A description of the action to be considered.

"**Action** means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. Examples include, but are not limited to: (a) actions intended to conserve listed species or their habitat;...(d) actions directly or indirectly causing modifications to the land, water, or air." (50 CFR 402.02).

Under 50 CFR 402.03 Applicability, it is stated that "Section 7 and the requirements of this part apply to all actions in which there is discretionary Federal involvement or control."

Thus the Federal action addressed by this BA and the formal section 7 consultation under provisions of the ESA are those discretionary functions within the authority of the Secretary. Based on the perponderence of the public comments on the March 1996 draft of this document, it is necessary to clearly distinguish between the Secretary's non-discretionary and discretionary authorities. This distinction is discussed in detail in "Section II. Description of Action" portion of this document; however, a short introductory discussion is provided below.

The Secretary's discretionary management of the lower Colorado River, by Reclamation, is very limited through provisions contained in a number of compacts, Supreme Court decrees, international treaties, various statutes, and contracts between the United States and water entitlement holders and power customers. Again, these and other requirements are collectively known as the "Law of the River" (Table 1). In meeting these decree, treaty, and other obligations, the Secretary does have some meaningful, but limited, discretion in how water andpower are managed, depending on the situation, on a short-term basis in lakes and river reaches.

During a "normal" water year and assuming no problems with non-beneficial use, waste, or system failures, the Secretary is obligated to deliver at least 9 million acre-feet (maf) of water to the three lower basin States of Arizona, California, and Nevada (total 7.5 maf) and to Mexico (1.5 maf). Pursuant to the Boulder Canyon Project Act (43 U.S.C. § 617 et seq.), the Secretary has executed contracts with the States of Nevada and Arizona for 300,000 acre-feet and 2.8 maf, respectively. Within each State, including California, there are numerous entities that have Federal reserved water rights, pre-1929 present perfected water rights recognized in the Supreme Court's decrees, or permanent service contracts with the Secretary executed under section 5 of the Boulder Canyon Project Act. The United States also has treaty obligations to deliver water to Mexico.

Due to these mandates and obligations, the Secretary must deliver water entitlements when the water is ordered. This applies to all water entitlement holders, whether an Indian tribe, irrigation district, wildlife refuge, municipality, national recreation area, or Mexico. In doing so, the Secretary exercises discretion, although it is usually narrow, in how water is stored in system reservoirs and released through Federal facilities. Deliveries are determined by specific water delivery orders and are patterned under contractual obligations for power generation at Hoover, Davis, and Parker Dam's hydropower generation facilities.

Additionally, the Secretary exercises limited discretion in managing flood events but has considerable discretion over river maintenance and Section 7(a)(1) [ESA] endangered species conservation measures.

b. Area: "A description of the specific area that may be affected by the action."

"**Action area** means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." [50 CFR 402.02]. It should be noted that the CFR definitions of "action" and "action area" differ, with the latter addressing geographical scope.

The geographical area of the discretionary actions under this section 7 consultation is the lower Colorado River from Lake Mead to the SIB, with the lateral boundary defined by the designated critical habitat (reservoirs to full pool elevation or the 100-year flood plain) for the endangered razorback sucker and bonytail (Figure 3). Non-Federal actions outside the geographical area, such as the diversion and use of reserved and present perfected water rights, are discussed under "Section III. Environmental Baseline."

c. Species and Critical Habitat Description: "A description of any listed species or critical habitat that may be affected by the action."

In response to Reclamation's request for a species list, FWS, via fax transmission dated February 24, 1995, provided a list of potentially occurring species in Reclamation's operational area: 7 endangered species, 1 proposed endangered species, and 27 candidate species. Since the receipt of this list, the southwestern willow flycatcher was listed as endangered on March 29, 1995 (FR, Vol. 60, No. 38, February 27, 1995), and the bald eagle was down listed from endangered to threatened (FR, Vol. 60, No. 133, July 12, 1995). Also, Reclamation was advised on June 13, 1995, that the California black rail was a candidate species (Ted Cordery, pers. comm.). At an August 17, 1995, meeting of the species conservation plan work group (now MSCP), which included representatives of FWS, Reclamation discussed 1) that its species list had expanded to include the threatened Mohave population of the desert tortoise, four additional candidate species, and one species of concern to California, as well as, the designated critical habitat for the razorback sucker and bonytail, and 2) that it needed additional time to complete its baseline description of operations, maintenance, resources, and to conduct the effect analysis.

In responding to Reclamation's memorandums dated December 26, 1995, and February 15, 1996, FWS memorandum dated March 19, 1996, concluded that "The Service does not have any additions to the list of threatened or endangered species contained in the document [Description of Operations...December 1995] for the United States portion of the Colorado River." However, in its memorandum FWS identified three Mexico species (desert pupfish, Vaquita or Gulf of California [Gulf] harbor porpoise, and totoaba) that "...should be included in the list of species for the consultation." Additionally, the FWS memorandum notified Reclamation that none of the sensitive species (32 former category 1 or 2 species) are among the FWS February 28, 1996, Notice of Review for species regarded as candidates for possible listing as endangered and threatened wildlife and plants under the ESA. As part of the public review process, Reclamation has also been requested to address the flat-tailed horned lizard, a species that has been proposed for listing as threatened. Consequently, this document addresses the potential effects of the "action" on 7 endangered species, 2 threatened species, 1 proposed threatened species, and 32 sensitive species in the United States. Three endangered species in Mexico are also discussed; one of which, the endangered desert pupfish, is also discussed under cumulative effects in the United States. These species are listed in Table 2 and are discussed in Section IV of this document.

Due to its range being outside the potential influence of the actions being addressed in this BA, the Hualapai southern pocket gopher has not been included in this final document. Also, during the public review of the draft BA, Reclamation received suggestions for the inclusion of additional species. With the limited time to complete this document and the lack of official ESA protection for these additional species, Reclamation was unable to include such species as suggested.

By letter dated April 10, 1996, Reclamation provided the National Marine Fisheries Service (NMFS) a copy of the March 1996 draft of this BA. In its June 28, 1996, letter, NMFS indicated that the totoaba and vaquita were under its jurisdiction as endangered under ESA. They determined that the vaquita and four species of listed sea turtles are not likely to be adversely affected by Reclamation's lower Colorado River operations. In terms of the totoaba, NMFS indicated that Reclamation's operations may potentially affect this species but requested additional information regarding treaty obligations and the Secretary's discretion concerning the delivery of Mexican Treaty water. This information is provided in Sections II and IV (totoaba discussion) of this document.

The temporal scope for this section 7 consultation on Colorado River operations and maintenance is for a period of up to 5 years, or until the long-term MSCP is developed, whichever comes first. Due to the scope and complexity of issues involved on such a large river system, it is felt that the time frame of "up to 5 years" is necessary to formulate and implement a comprehensive, efficacious MSCP. It is expected that the MSCP will be developed and implemented well within this time frame and that interim conservation measures and/or any potential reasonable and prudent alternatives and measures proposed by FWS, as a result of this consultation, will address the needs of listed species and designated critical habitat during the development of the MSCP. Under the "reinitiation of formal consultation" provisions of 50 CFR 402.16, Reclamation will re-consult prior to the end of the 5-year period on its discretionary involvement or control over the action under consultation, or its implementation of its portion of the MSCP.

Critical habitat, as defined in section 3(5)(A) of the ESA, means "(i) the specific areas within the geographical area occupied by the species at the time it is listed..., on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by a species at the time it is listed..., upon a determination by the Secretary that such areas are essential for the conservation of the species." "Conservation," as defined by section 3(3), ESA, means "...the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary."

On April 20, 1994, much of the mainstream Colorado River from Lake Mead to Imperial Dam was designated as critical habitat for either or both the razorback sucker and bonytail (FR, Vol. 59, No. 54, March 21, 1994) (Figure 3). Of the original critical habitat proposal, only the "Davis Dam to the upstream end of Topock Marsh on the mainstream Colorado River" was determined "separable" and not designated as critical habitat.

The primary constituent elements used to define critical habitat for the razorback sucker and bonytail are water, physical habitat, and biological environment (FR, Vol. 58, No. 18, January 29, 1993). The lateral boundary of the designated critical habitat includes Lakes Mead, Mohave, and Havasu "...to their full pool elevations," and those portions of the 100-year flood plain that contain the constituent elements. Five additional selection criteria,

primarily habitat requirements for reproduction and recruitment and special management or protection needs, were used to designate critical habitat for the razorback sucker (FR, Vol. 59, No. 54, March 21, 1994).

d. Effects of the Action: "A description of the manner in which the action may affect any listed species or critical habitat and an analysis of any cumulative effects."

Again, 50 CFR 402.02 provides definitions of potential effects of the action. These are:

"Effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the baseline." Direct and indirect effects are discussed in Section IV for each species and critical habitat. Due to the various laws, decrees, and other directives associated with the "Law of the River," Reclamation considers the diversion and distribution of entitlement waters, subject to beneficial use and waste determinations, as not being under the meaningful discretion of the Secretary and, therefore, such non-Federal actions are not considered as interrelated or interdependent actions. However, they are considered as being contemporaneous and cumulative to the action under consultation and are addressed as such in "Section III. Environmental Baseline." Also, past and on going ESA compliance for authorized Reclamation projects (e.g., Central Arizona Project (CAP), Robert B. Griffith Water Project, and Front Work and Levee System Project) are summarized as part of the environmental baseline.

"The **environmental baseline** includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process." The environmental baseline is a complex and difficult issue not only to identify, but to quantify historically. Many reviewers of the March 1996 draft of this document recommended that the description of the environmental baseline be improved. In responding to specific and general comments, Section II of this document has been revised to provide a chronology of major events on the lower Colorado River, additional description on temporal changes in flora and fauna, an expanded review of past and other ongoing consultations, and a discussion of contemporaneous (e.g., diversion and distribution of entitlement waters) and cumulative activities (future, reasonably certain to occur non-Federal actions). Although Section III addresses much of the baseline, a full picture of the environmental base line will require the inclusion of water management (e.g., historical and present hydrography) of Section II and current species range and status in section IV. Effects due to the Secretary's non-discretionary actions are considered as part of the baseline.

"**Indirect effects** are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur."

"**Cumulative effects** are those effects of **future** State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." As part of the public review of the March 1996 draft of this document, reviewers were requested to provide information regarding future and reasonably certain to occur non-Federal activities for inclusion in the final of this BA. Notification of specific actions was not received as part of the public review process. Reclamation has attempted to identify potentially contemporaneous and future cumulative actions in Section III and, to the greatest extent practicable, has provided cumulative effect discussions for each ESA-listed species discussed in Section IV of this document. The diversion and distribution of entitlement waters in the United States is discussed in Section III as contemporaneous and future cumulative actions.

The FWS Draft Endangered Species Consultation Handbook (November 1994) defines **"Direct Effects"** as encompassing the direct or immediate effect of the project on the species or its habitat. Additionally the handbook states "Direct effects result from the agency action including the effects of interrelated actions and interdependent actions." Direct effects are discussed for each ESA-protected species in Section IV.

e. Relevant Reports: "Relevant reports, including any environmental impact statement, environmental assessment, or biological assessment prepared....."

Based on comments provided via written reviews of the March 1996 draft of this document, additional relevant reports have been cited in this document. FWS has been provided copies of all written public comments on the draft BA. Additionally, FWS is aware of its recovery plans and FR notices of proposed and final notices of listings and critical habitat designations for the species and critical habitats included in this BA and previous formal section 7 consultations.

f. Other Relevant Reports: "Any other relevant available information on the action, the affected listed species, or critical habitat."

Reclamation will also provide sets of maps depicting the most recent (1994) vegetation classification and front work and levee system features for FWS reference.

3. Public Process and Consultation Schedule

Due to the considerable interest that a variety of stakeholders have shown in this section 7 consultation on lower Colorado River operations, Reclamation has committed to making the consultation process with FWS fully public. Normally, such section 7 consultations are conducted only between the action agency and FWS. The final biological opinion from FWS on this consultation is scheduled for April 15, 1997. A Consultation Agreement, which outlines a schedule of events and provides for public involvement, was signed on March 29, 1996, by representatives of Reclamation and FWS; a copy of that Agreement is provided as Appendix B.

Pursuant to commitments in the Consultation Agreement, Reclamation provided a 30-day public review and held a public meeting (May 3, 1996) on the March 1996 draft BA. A summary of the public meeting and copies of the 29 written comments on the draft BA have been distributed (via memo dated June 10, 1996) to stakeholders on Reclamation's mailing list for this consultation.

Due to the number and technical extent of comments on the March 1996 draft of this document, Reclamation has employed additional resources and time to significantly modify this final BA. This major modification has delayed Reclamation's completion of the BA and its submittal to FWS for formal consultation beyond the estimated date of June 30, 1996 (Step 3 of Consultation Agreement). FWS was notified of this rescheduling via Reclamation's memorandum dated June 28, 1996 and verbal communication on July 24, 1996. However, the April 15, 1997, deadline (Step 8, Consultation Agreement) for issuance of the final biological opinion will not be changed.

II. DESCRIPTION OF ACTION

A. Introduction

This chapter of the assessment provides a descriptive overview of Reclamation's role on the lower Colorado River. Four specific areas are addressed: 1) an overview of the river and its operational facilities, 2) Reclamation's discretionary role, acting on behalf of the Secretary, in implementing the Law of the River, 3) an overview of current river operation and maintenance activities employed by Reclamation to implement the Law of the River, 4) Reclamation activities under section 7(a)(1) of the ESA conserving threatened and endangered species, and 5) a summary.

Most of the lower Colorado River's water, or about 96 percent of the annual supply, flows into the lower basin at Lees Ferry from the upper basin. The mean annual flow at Lees Ferry between 1935 and 1990 was about 10,165,000 acre-feet. The remaining 4 percent came from side flows during rainstorms and tributary rivers in the lower basin. Colorado River water flows are highly variable from year to year and the mean annual inflow is about 472,700 acre-feet. Figure 4 illustrates the quantities of lower Colorado River water released and diverted yearly.

The Law of the River requires the United States to operate the lower Colorado River with the following three main priorities: 1) for river regulation, improvement of navigation, and flood control, 2) for irrigation and domestic uses, including the satisfaction of present perfected rights, and 3) for power. Water cannot be released unless there is a valid beneficial use for the water, and it is then released at a time and in a way to meet the water delivery need, and to maximize other benefits including power production. Beyond these requirements, the United States takes into consideration such other needs on the river as recreation, wildlife, water quality, and species conservation. The facilities which were built to enable meeting these requirements are shown in Figure 5. More-detailed descriptions of these structures and others are provided in "Appendix D - Major Facilities on the lower Colorado River".

Hoover Dam is the northernmost Reclamation facility on the lower Colorado River and is located 68 miles downstream from Pierce Ferry. The dam provides flood control protection and the reservoir it forms provides the majority of the storage capacity for the lower basin. The dam's four intake towers draw water from reservoir elevations above 895 feet and drive 17 generators within the dam's powerplant. Maximum water flow rate through the generators is approximately 49,000 cubic feet per second (cfs). Lake Mead, the name of the reservoir behind Hoover Dam, can store 31,250,000 acre-feet of water up to an elevation of 1,221 feet at the top of the dam's spillway gates. Lake Mead's surface area is 162,700 acres when full. Water is diverted from, and some water is returned to, Lake Mead for use in southern Nevada for domestic purposes by the Southern Nevada Water Authority and other users.

Davis Dam is located 67 miles below Hoover Dam and operates as a re-regulation facility and powerplant. Lake Mohave behind Davis Dam can store up to 1,818,300 acre-feet of water at a maximum elevation of 647 feet. When full, Lake Mohave covers 28,500 acres and backs water 67 miles upstream to the tailrace, or the water outlet, of Hoover Dam. Water is released through Davis Dam's five generators from lake elevations potentially as low as 570 feet, and the maximum efficient rate of flow through the generators is 28,000 cfs. Water is diverted and pumped from Lake Mohave for domestic uses. Typical water travel time from Hoover Dam to Davis Dam is 4 to 6 hours.

Parker Dam is located 88 miles downstream from Davis Dam and operates as a forebay and desilting basin for the Colorado River Aqueduct and the CAP. Lake Havasu behind Parker Dam has a storage capacity of 648,000 acre-feet of water at a maximum lake elevation of 450 feet. When full, Lake Havasu backs water up-river for 45 miles and covers 20,400 acres. Lake Havasu is limited in its elevation and has only a 10-foot operational range between elevations 440 to 450 feet. Water above 400 feet in elevation is diverted through the powerplant's four generators with a maximum efficient flow rate of 19,000 cfs. Water diverted from the lake is delivered by The Metropolitan Water District of Southern California (MWD) through its Colorado River Aqueduct to southern California and through the Granite Reef Aqueduct by the Central Arizona Water Conservation District (CAWCD) to central Arizona. Water is also diverted and pumped above Parker Dam for domestic, irrigation, and environmental uses. Typical water travel time from Davis Dam to Parker Dam is just over 1 to 1.5 days.

Headgate Rock Dam is located 14 miles downstream from Parker Dam and was constructed in 1942 for the Bureau of

Indian Affairs as a diversion facility for the Colorado River Indian Tribes (CRIT) Reservation. The dam was recently retrofitted to provide power generation capability. Lake Moovalya behind the dam has limited water storage capacity and is occasionally drained during the winter for diversion-canal maintenance. The maximum elevation of Lake Moovalya is 364 feet and backs water up for 10 miles. Water from a maximum depth of 15 feet is released though several generators with a combined flow rate of 20,000 cfs. Water is diverted by gravity immediately behind the dam though the CRIT canal for use on the CRIT reservation. Water is also diverted and pumped from Lake Moovalya for domestic, irrigation, and environmental uses. Typical water travel time from Parker Dam to Headgate Rock Dam is 1 to 4 hours.

Palo Verde Diversion Dam is located 44 miles downstream of Headgate Rock Dam and was constructed between 1956 and 1957 as a diversion dam to replace and improve the reliability of the Palo Verde Irrigation District's (PVID) original gravity diversion facilities. Storing water to a maximum 46-foot depth, the dam has no effective water storage or flood control capability. Water is diverted by gravity immediately above the dam though the PVID canal. The canal can transport a maximum flow of 1,800 cfs. Water also is diverted and pumped above Palo Verde Diversion Dam for domestic, irrigation, and environmental uses. Typical water travel time from Headgate Rock Dam to Palo Verde Diversion Dam is about 1 day.

Senator Wash Dam and Reservoir is located 85 miles downstream from Palo Verde Diversion Dam and 2 miles upstream from Imperial Dam. The purpose of this off-stream pump-storage facility is to improve water delivery reliability and to reduce waste of Colorado River water when water orders change or precipitation causes side-channel inflow. The facility allows Reclamation to capture and store water not needed for delivery below Parker Dam or to release water if demands are greater than the existing river supply.

Imperial Dam is located 90 miles downstream of Palo Verde Diversion Dam or 147 miles downstream of Parker Dam (the last storage or regulation facility). Imperial Dam was built between 1936 to 1940 as a gravity diversion facility for the All-American Canal, to replace the original Alamo Canal, and as a diversion facility for the Gila Gravity Main Canal. Imperial Dam has no effective storage or flood control capability and stores water to a maximum depth of 23 feet. Water is released though the dam though the sluiceway gates. The All-American Canal can transport a maximum water flow of 15,155 cfs and supplies water to the Imperial Irrigation District (IID), the Coachella Valley Water District (CVWD), and other small users. The Gila Gravity Main Canal can transport up to 2,200 cfs and supplies water to the Wellton-Mohawk Irrigation and Drainage District (WMIDD) and to the Yuma area. Water also is diverted and pumped between Palo Verde Diversion Dam and Imperial Dam for domestic, irrigation, and environmental uses. Typical water travel time from Palo Verde Diversion Dam to Imperial Dam is about 2 days.

Laguna Dam is located 5 miles downstream of Imperial Dam and was constructed between 1905 and 1909 as part of the Yuma Project to provide for gravity diversion of Colorado River water. However, with the construction of Imperial Dam immediately upstream, the Yuma Project was reconfigured in June 1948 to use Imperial Dam for the Gila Gravity Canal diversion. The dam creates Mittry Lake and impounds water to a depth of 10 feet at a surface elevation of 154 feet. Today Laguna Dam serves as a regulating structure for sluicing flows controlling downstream sediment and helps meet Mexico's water delivery orders. Typical water travel time from Imperial Dam to Laguna Dam is about 2 hours.

Morelos Dam is located 22 miles downstream of Laguna Dam and is the primary Colorado River water diversion facility for Mexico. The water is transported into the Alamo Canal for use in Mexico. The dam has no effective storage or flood control capacity. Morelos Dam was built, and is operated and maintained, by Mexico. Typical water travel time from Laguna Dam to Morelos Dam is about 6 hours.

The Limitrophe Division is the 22-mile reach of the river that borders Mexico and extends from Morelos Dam to the SIB near San Luis, Arizona. The division is essentially dry during normal years due to the diversion of water by Mexico at Morelos Dam.

B. The Secretary's Discretionary Management Activities

This section presents a condensed description of those activities of the Secretary, acting either directly or through Reclamation, undertaken in the operation and maintenance of the lower Colorado River and its reservoirs. This information is provided to establish an understanding of those activities and to provide a basis for an informed biological opinion determination on the effects of the appropriate operational and maintenance activities on the lower Colorado River system.

In accordance with the ESA and the attendant FWS CFR regulations, and for the purpose of establishing the action under consultation, this subsection specifically identifies future Reclamation activities which are discretionary and differentiates as non-discretionary those activities mandated by law, Court decrees, settlement acts, codified regulations, contracts, or other legal requirements.

The following discussions differentiate between the Secretary's discretionary and non-discretionary authority for each of the major actions addressed by this BA. Conservation measures under section 7(a)(1) of the ESA have been described as discretionary.

1. Flood Control

The Boulder Canyon Project Act of 1928 (December 21, 1928, 45 Stat. 1057; 43 U.S.C. § 617) and the Flood Control Act of 1944 (December 22, 1944, 58 Stat. 890; 33 U.S.C. § 709) provided for flood control activities in the lower Colorado River. Flood control operations have the first priority on the lower Colorado River as mandated by the Boulder Canyon Project Act.

Section 2(b) of the Boulder Canyon Project Act allocated funds for flood control for the construction of Hoover Dam. Subsequently, section 7 of the Flood Control Act of 1944 established that the Secretary of War (now the Army Corps of Engineers [COE]) will prescribe regulations for flood control for projects authorized, wholly or in part, for such purposes.

The Los Angeles District of the COE published the current flood control regulations in the "Water Control Manual for Flood Control Hoover Dam and Lake Mead Colorado River, Nevada and Arizona" dated December 1982. The Field Working Agreement between the COE and Reclamation for the flood control operation of Hoover Dam and Lake Mead, as prescribed by the manual, was signed on February 8, 1984, and is included as Appendix H of this BA. The next review and possible revision of the flood control manual will occur within the next 5 years. Reclamation cannot predict the content of that review or the product thereof; thus those biological impacts will be addressed separately from this document.

The process of establishing the flood control regulations encompasses an analysis of the facts and the application of the best available technology. Within that framework, the COE must weigh and balance the various factors and has the responsibility for any discretionary decisions resulting in the flood control regulations. The COE conducts oversight activities when Hoover Dam is in flood operations. The Secretary has no discretion in making the minimum flood control releases from Lake Mead through Hoover Dam during flood control operations. When the required minimum flood control releases are less than the required releases for downstream water uses, the additional increment released to meet those uses is released by the Secretary in his role as Watermaster.

An analysis of the "Water Control Manual for Flood Control Hoover Dam and Lake Mead Colorado River, Nevada and Arizona" reveals that of the various triggers for releases studied in the preparation of the manual, very little difference was identified in the river flows under the different scenarios, except in extreme and rare events. The major effects occurred in upper basin storage, with resultant changes in the probability of a system drought.

A description of the operation process for flood control for Hoover Dam is presented in part C.1 entitled "Flood Control" of this document.

The COE is not responsible for the flood control criteria related to Davis Dam and Parker Dam, although the respective lake elevations and the operation of Davis Dam and Parker Dam are affected and, in part, determined by the flood control releases from Hoover Dam. The decision to include flood control as an operational parameter and the operation of the flood control aspects of Davis and Parker Dams fall within the Secretary's discretion. In another sense, the inclusion of the flood control aspects of Davis and Parker Dams is prescribed in the Law of the River, for the waters entering the system via tributary runoff become mainstream water, and the release of these waters is subject to the requirements and prohibitions placed upon the Court decree further described in this section. The discretionary component of operational water elevation levels of Davis Dam and Parker Dam, which reflect flood control as one of the parameters and as prescribed by Reclamation for Davis Dam and Parker Dam, are shown in Figures 15 (Lake Havasu Operational Constraints) and 17 (Lake Mohave Operational Constraints) and are within the scope of this consultation.

2. The Role of the Secretary as Watermaster of the Lower Colorado River Basin for Delivery and Storage of Water

Over the past 74 years, the upper and lower basins and the associated body of laws, Court decrees, regulations, and contracts have developed into two very different bodies of law for the upper and lower basins. The following synopsis establishes the authority and operational framework of the Secretary in the operation of the lower Colorado River basin. Reclamation serves as the representative of the Secretary in the implementation of these responsibilities.

The Colorado River Compact of 1922 divided the Colorado River into an upper and lower Basin, and Article III(a) provided 7.5 maf of water to the lower basin States. Article III(b) gave the lower basin right to increase its beneficial consumptive use of water by 1 maf per year. Article III(c) requires that the burden of any deficiency in meeting international commitments for supplying Colorado River water to Mexico shall be borne equally between the upper basin and lower basin. Article III(d) requires that the upper basin States will not cause the flow of the river at Lees Ferry to be depleted below an aggregate of 75 maf for any 10 consecutive years. Article III(e) states that water will not be withheld by the upper basin States or delivery required by the lower basin States, that cannot reasonably be applied to domestic and agricultural uses.

The Boulder Canyon Project Act of 1928 federalized the lower basin and established the Secretary as the Watermaster. The act made a mainstream basic apportionment of 7.5 maf to the three lower Division States in the following manner: Arizona 2.8 maf, California 4.4 maf, and Nevada 300,000 acre-feet of consumptive use per year. The act requires that all of the entitlements to Colorado River water existing as of the effective date of the act be met prior to anyone else receiving any additional Colorado River water. It requires that all parties using Colorado River water shall have a contract with the Secretary for the use of Colorado River water and the contract term shall be for permanent service. The Secretary is prohibited from releasing any Colorado River water unless the water is scheduled by an entitlement holder for beneficial use or the water is released for flood control releases. Section 13(a) approved the 1922 Compact,and Section 16 requires the Secretary to consult with the States.

The Mexican Water Treaty of 1944 (between the United States of America and the United States of Mexico) further defined the apportionment of Colorado River water.

The United States Supreme Court Decrees in Arizona vs. California, et al., of 1964, 1979, 1984.

The 1964 Decree, in Article II, states "The United States, its officers, attorneys, agents and employees are hereby severally enjoined:

> "(A) From operating regulatory structures controlled by the United States and from releasing water controlled by the United States other than in accordance with the following order of priority:
>
> (1) For river regulation, improvement of navigation, and flood control;
>
> (2) For irrigation and domestic uses, including the satisfaction of present perfected rights; and
>
> (3) For power;
>
> "Provided, however, the United States may release water in satisfaction of its obligations to the United States of Mexico under the treaty dated February 3, 1944, without regard to the priorities specified in this subdivision (A);
>
> "(B) From releasing water controlled by the United States for irrigation and domestic use in the States of Arizona, California and Nevada, except as follows:

(1) If sufficient mainstream water is available for release, as determined by the Secretary of the Interior, to satisfy 7,500,000 acre-feet of annual consumptive use in the aforesaid three states, then of such 7,500,000 acre feet of consumptive use, there shall be apportioned 2,800,000 acre feet for use in Arizona, 4,400,000 acre feet for use in California, and 300,000 acre feet for use in Nevada;

(2) If sufficient mainstream water is available for release, as determined by the Secretary of the Interior, to satisfy annual consumptive use in the aforesaid states in excess of 7,500,000 acre feet, such excess consumptive use is surplus, and 50% thereof shall be apportioned for use in Arizona and 50% for use in California; provided, however, that if the United States so contracts with Nevada, then 46% of such surplus shall be apportioned for use in Arizona and 4% for use in Nevada;

(3) If insufficient mainstream water is available for release, as determined by the Secretary of the Interior, to satisfy annual consumptive use of 7,500,000 acre feet in the aforesaid three states, then the Secretary of the Interior, after providing for satisfaction of present perfected rights in the order of their priority dates without regard to state lines and after consultation with the parties to major contracts and such representatives as the respective states may designate, may apportion the amount remaining available for consumptive use in such manner as is consistent with the Boulder Canyon Project Act as interpreted by the opinion of this Court herein, and with other applicable federal statutes, but in no event shall more than 4,400,000 acre feet be apportioned for use in California including present perfected rights;

(4) Any mainstream water consumptively used within a state shall be charged to its apportionment, regardless of the purpose for which it was released;

(5) Notwithstanding the provisions of Paragraphs (1) through (4) of this subdivision (B), mainstream water shall be released or delivered to water users (including but not limited to, public and municipal corporations and other public agencies) in Arizona, California, and Nevada only pursuant to valid contracts therefore made with such users by the Secretary of the Interior, pursuant to Section 5 of the Boulder Canyon Project Act or any other applicable federal statute;

(6) If, in any one year, water apportioned for consumptive use in a state will not be consumed in that state, whether for the reason that delivery contracts for the full amount of the state's apportionment are not in effect or that users cannot apply all of such water to beneficial use, or for any other reason, nothing in this decree shall be construed as prohibiting the Secretary of the Interior from releasing such apportioned but unused water during such year for consumptive use in the other states. No rights to recurrent use of such water shall accrue by reason of the use thereof;"

Therefore, based on the Law of the River, entitlements to the beneficial use of Colorado River water in the lower basin have been established in the following four ways.

1. Court decrees for 4,156,847 acre-feet which includes the water rights perfected by the States and which existed prior to the effective date of the Boulder Canyon Project, Indian Reservations water entitlements, and other Federal entitlements listed in the Court decrees.

2. Secretarial reservations for Federal uses, such as the Bureau of Land Management (BLM), FWS, and Reclamation.

3. Contractual entitlements under section 5 of the Boulder Canyon Project Act.

4. The International Treaty with Mexico for 1.5 maf.

The Secretary is responsible for managing the lower basin and for providing for the delivery of Colorado River water entitlements to entitlement holders. A water delivery contract with the Secretary secures and protects the entitlement holder as the contract quantifies the amount of Colorado River water the entitlement holder is entitled to beneficially use and states the priority of that water use.

Secretarial determinations are based upon the decision whether conditions meet a "normal year," "surplus year," or "shortage year" as prescribed by the associated law and requirements. For the purposes of this document, a normal year is when the Secretary determines that there is sufficient mainstream water to satisfy the annual pumping and releases from Lake Mead to satisfy 7.5 maf of annual consumptive use in the lower basin, plus 1.5 maf for Mexico. A surplus year is when the Secretary determines that there is more water available than in a normal year, and a shortage year is when the Secretary determines that there is less water available than in a normal year. When an entitlement holder schedules water in a normal year or surplus year, the Secretary has no option but to deliver the water as prescribed by law and contract in the amounts and at the times requested, so long as it does not exceed that reasonably required for beneficial consumptive use. In a shortage year, the Secretary is required to consult with the affected parties and then factor in the shortages as prescribed by law and contract. These actions may be perceived to be discretionary, but, as required by law, there is a process of consultation based on water conditions. To date, a surplus has not been declared: however, within the next 5 years such a declaration is possible.

The Secretary is required by Article V of the Supreme Court decree to keep a record of all Colorado River water diversions, returns, and consumptive use, along with other water-related data, and to make that information available to interested parties at least annually. The water accounting function is non discretionary; whereas, the method or process utilized to collect and publish the report may be discretionary.

Typically, water schedules are placed by entitlement holders in advance. Some water schedules are placed a month in advance and call for daily, and sometimes hourly, water volumes. The advance schedules may be revised or changed at the request of the entitlement holder. Since water entitlement contracts are for perpetuity, the water schedule terms and conditions may vary due to the effective date of the contract. Some of the contracts have a maximum rate of diversion in terms of cfs, approved points of diversion(s), and authorized type of water use or place of water use. The Secretary adopted the 1931 California Seven Party Agreement for 5,362,000 acre-feet of water and entered into a master contract with the State of Nevada in 1942 for 300,000 acre-feet of water and with the State of Arizona in 1944 for the 2,800,000 acre-feet of water. These actions effectively allocated 8,462,000 acre-feet of the lower Colorado River basin's water for use in the United States by 1944. A detailed description of the process for handling water orders is presented below in part C.1.d..

The level of Secretarial discretion, if any, related to a water entitlement is directly related to the type of entitlement. For example, the Supreme Court-decreed entitlements with the five Indian Tribes, FWS, and the National Park Service (NPS) have never been incorporated into administrative agreements or contracts. In fact, as long as the water is used at the decreed place of use and those entitlement holders do not request a change or a new benefit, the Secretary has extremely limited control over these entitlements. Other present perfected right entitlement holders, as listed in the Supreme Court decree, may or may not have an administrative agreement (contract) with the Secretary; the terms and conditions of such a contract for present perfected rights are few.

Therefore, the amount of control or discretion the Secretary has over any one entitlement ranges from very limited to extremely limited, varies by the type of the entitlement, and depends upon the execution date of the contract and its associated terms and conditions. Secretarial actions must not conflict with the contract terms or the mandates of the Court decree from which the Secretary is severally enjoined.

The Secretary may have limited discretion over such conditions as non-use, non beneficial use, or water conservation. However, the Secretary has no effective meaningful discretion over meeting an entitlement holder's valid request for water for beneficial use. This holds true for a municipality, irrigation district, Indian Tribe, or wildlife refuge. The Secretary may have limited flexibility regarding when water is released from Lake Mead, based on a minor amount of storage capacity in the downstream reservoirs for re-regulation.

The Regional Director of Reclamation's Lower Colorado Region, on behalf of the Secretary in his Watermaster role, may make annual determinations relating to water conservation measures and delivery, distribution, and use of Colorado River water pursuant to 43 CFR Part 417. Deliveries of Colorado River water will not exceed those reasonably required for beneficial use.

The following actions are discretionary:

- determination of which contractors will be consulted (may exclude contractors and permittees of small quantities of water and contractors for municipal and industrial water),

- determination that water orders are, or are not, within that reasonably required for beneficial use, and

- the amount water orders are reduced if determined to be within that reasonably required for beneficial use.

The discretionary actions associated with the use of Colorado River water relate to non-consumptive water uses for which Reclamation is not severally enjoined. For example, such non-consumptive uses could include, recreation on the reservoirs and the Colorado River, increased flushing flows at Topock Marsh, and fish habitat within or adjacent to the mainstream of the Colorado River (such as Three-Fingers Lake). If any of the activities would have a consumptive use, the party responsible for the use would have to acquire a water entitlement to account for the water consumptively used as required by the Court decree.

It should be noted that the restrictions and obligations in the laws and decrees are so encompassing that the Senator Wash re-regulating reservoir was authorized and constructed to help meet the mandatory requirements for water delivery. Similarly, the storage and resultant elevations of Lake Mohave and Lake Havasu are used to re-regulate the local storm waters and last minute changes in water orders. These re-regulations are minuscule compared to the river's total flow and are therefore unmeasurable. However, within very narrow confines, the management of the lake levels of these three facilities may be considered discretionary.

On average, 96 percent of the water in the lower basin enters the system at Lee Ferry, and the remaining 4 percent comes from side flows into the system from the rivers or occasional rain flows. According to the Law of the River, this remaining 4 percent becomes Colorado River mainstream water when commingled with the Colorado River or its associated underground water aquifer and is subject to the same restraints.

The Secretary's role in the lower Colorado River basin, regarding water storage and the delivery of water apportionments and entitlements throughout the system, is subject to the Law of the River which includes the 1922 Compact, the Boulder Canyon Project Act, the 1964 Supreme Court decree, and contracts, settlement decrees, and applicable Federal and State law.

3. Declaration of Surplus

The Secretary, under the powers vested by Congress in Section 5 of the Boulder Canyon Project Act, as confirmed by Section II(B)(2) of the 1964 Decree, has certain discretionary authority to determine when more than 7.5 maf of Colorado River water is available for consumptive use during a calendar year in the three lower Division States; this is a surplus determination. When making this determination, the Secretary must consider all relevant factors as specified in Section III(3)(b) of the long-range operating criteria, including, but not limited to, the following conditions.

- Mexican Treaty obligations,

- Reasonable consumptive use requirements of mainstream water users in the lower basin,

- Net river losses,

- Net reservoir losses,

- Regulatory wastes,

- Requests for water by holders of water delivery contracts within the United States, and of other rights recognized in the Court decree,

- Actual and forecast quantities of active storage in Lake Mead and the upper basin storage reservoirs, and

- Estimated net inflow to Lake Mead.

Pursuant to the decree, water in excess of 7.5 maf consumptive use is apportioned 50 percent to California, 46 percent to Arizona, and 4 percent to Nevada. If a State will not use all of its apportioned water for the year, the Secretary may allow the other States to use the unused apportionment in that year, as outlined in Section II(B)(6) of the Court decree. Unused apportionment means Colorado River water within a lower basin State's basic or surplus apportionment, or both, which is not put to beneficial consumptive use in that year within that State. The decree in Section II(B)(6) specifically says that a right to the recurrent use of unused apportionment cannot accrue by reason of the use thereof. The unused apportionment water can be used when declared available by the Secretary; the use must be provided for by a contract with the Secretary and must be considered a beneficial use. Unused apportionment water may be withdrawn, subject to a 30-day written notice.

The Secretary also has the discretion to determine if the system conditions warrant supplying less than 7.5 maf for consumptive use, referred to as a shortage; a shortage has never been declared and is not expected within the next 5 years.

4. Delivery to Mexico at the Northerly International Boundary (NIB)

The minimum and maximum water flow rates (average monthly flow rates in cfs) at the NIB are the sum of the minimum and maximum flow rates specified in the Mexican Water Treaty of 1944:

- Article 15 Schedule 1 (delivery of 1,125,000 acre-feet annually in the Limitrophe section of the Colorado River), and

- Schedule 2 (delivery of 375,000 acre-feet annually at the boundary line by means of the All-American Canal); found on pages 30, 31, and 32 of the Mexican Water Treaty.

The annual delivery at the NIB is approximately 1,360,000 acre-feet annually (Minute 242). The minimum and maximum water flow rates in cfs and the corresponding acre-feet for delivery to Mexico at the NIB are shown in Table 3.

Table 3. Minimum and maximum flow rates for the delivery of water to Mexico at the NIB

Month	Minimum (cfs and acre-feet)	Maximum (cfs and acre-feet)
January	900 / 55,340	5,500 / 338,187
February	900 / 49,984	5,500 / 305,459
March	1,500 / 92,233	5,500 / 338,187
April	1,500 / 89,258	5,500 / 327,278
May	1,500 / 92,233	5,500 / 338,187
June	1,500 / 89,258	5,500 / 327,278
July	1,500 / 92,233	5,500 / 338,187
August	1,500 / 92,233	5,500 / 338,187
September	1,500 / 89,258	5,500 / 327,278
October	900 / 55,340	5,500 / 338,187
November	900 / 55,546	5,500 / 327,278
December	900 / 55,340	5,500 / 338,187

5. Water Delivery to Mexico at the Land Boundary near San Luis, Sonora

The flow rate for the delivery of Colorado River water at the land boundary near San Luis is discussed in the Mexican Water Treaty of 1944. Article 15, Schedule I of the treaty states in part:

> "Should deliveries of water be made at a point on the land boundary near San Luis, Sonora, as provided in Article 11, such deliveries shall be made under a sub-schedule to be formulated and furnished by the Mexican Section [IBWC]. The quantities and monthly rates of deliveries under such sub-schedule shall be in proportion to those specified for Schedule I, unless otherwise agreed upon by the [IBWC] Commission."

Article 15, Schedule II, paragraph B of the treaty states in part:

> "If, by mutual agreement, any part of the quantities of water specified in this paragraph are delivered to Mexico at points on the land boundary otherwise than through the All-American Canal, the above quantities of water and rates of deliveries set out under Schedule II of this Article shall be correspondingly diminished."

6. Power Operations

Each of the major lower Colorado River hydroelectric facilities have legislative authorization for the production of electric power. Reclamation is the Federal agency authorized to produce this power. Water is released from Hoover Dam (approximate elevation 1,200 feet above mean sea level [msl]) through a combination of the 19 dedicated generator pipes into Lake Mohave (approximately 640 feet in elevation). Water is then released through Davis Dam through a combination of the five dedicated generator pipes into Lake Havasu (approximate elevation 448 feet). Since Parker Dam is the last major United States-owned, Reclamation-administered hydroelectric facility on the lower Colorado River and there is no other significant downstream storage, all releases scheduled from Parker Dam are in response to downstream water orders or reservoir regulation requirements.

Although Reclamation is the Federal agency authorized to produce this power, Western Area Power Administration (WAPA or Western) is the Federal agency authorized to market this power. WAPA enters into electric service contracts on behalf of the United States with private and municipal entities.

The topic of power operations in the lower basin must be prefaced with a discussion of the authorizing legislation for the DOE under Public Law 95-91 dated August 4, 1977. Section 302 of this law is entitled "Transfers from the Department of the Interior." Section 302(a)(1)(E) transferred from the Secretary of the Interior to the Secretary of Energy the following functions:

> "(E) the power marketing functions of the Bureau of Reclamation, including the construction, operation, and maintenance of transmission lines and attendant facilities;"

This is the legislative authority for the creation of WAPA. WAPA entered into a Joint Operating Agreement (JOA) with Reclamation's Lower Colorado Region dated February 8, 1980, to implement section 302(a)(1)(E) of Public Law 95-91. At the time, Reclamation was known as the Water and Power Resources Service (Service). The "System Operations" section of the JOA states in pertinent part:

> **"Service will adhere to Western's generation schedules** and cooperate with Western on operations and maintenance of Federal power facilities." [emphasis added]

This means that Reclamation is obligated to meet the Hoover, Parker, and Davis Dams' power generation schedules which are produced by WAPA in accordance with existing electric service contracts, subject to water availability. The released water generates power, but water is not released for the sole purpose of generating power. Even though the Parker-Davis electric service contracts were not signed by Reclamation representatives, the contractual obligations with respect to generation scheduling are Federal obligations, and Reclamation must adhere to WAPA's generation schedules as WAPA must produce these schedules in accordance with the electric service contracts. Reclamation does have the discretion to ask the electric service customers to renegotiate their contracts [If the United States is relieved of the electric service contractual obligations, then the United States could be responsible for direct financial reimbursement to the electric service contractors.] .

The General section of the JOA states in pertinent part: "Changes to the agreement and the appendices will be effected through Service's Regional Office and Western's Area Office." Any change to the JOA would have to be agreed upon by these two offices.

Parker and Davis Dams and Powerplants:

The authorizing legislation of these facilities required the generation of power and granted exclusive rights of the facility power capacity and energy to priority use power customers. "Capacity" in this usage means the electrical generating capacity of on-line generator units, whether or not they are actually producing power at any specific time. The capacity and energy utilized by the Parker-Davis electric service customers is termed "firm electric service power." The users have firm capacity and firm energy contracts with the United States which are in effect until midnight, mountain standard time, September 30, 2008. These contracts were signed by the Area Manager of WAPA's Boulder City Area Office (now known as the Regional Manager of Western's Desert Southwest Region). The Parker-Davis electric service contracts stipulate contract rates of delivery (CROD) for each firm electric service customer. The CROD for a contractor specifies the maximum number of whole or partial units that must be available to supply power to that customer at their specific point of power delivery. For example, if a specific hypothetical power customer had a Parker CROD of 30 megawatts (MW), it would be entitled to the output of three-quarters of a Parker generating unit (one whole Parker generator is 40MW) at any time during the applicable season (summer or winter) delivered to the contract-specified point of power delivery. There are contractual minimum summer CROD and winter CROD. The higher the seasonal CROD, the more electric generator units must be operated concurrently at the associated facility.

Each Parker-Davis electric service contract contains essentially the same language. As an example, subsection 5.1 of Contract No. 87-BCA-10108 with Yuma Irrigation District is entitled "Western's Energy and Capacity Obligations." Paragraph 5.1.1 of that subsection states in pertinent part: "The Contract Rate of Delivery will be available in any hour within the billing period." This means that if the "firm" electric service customer requests a capacity within its minimum seasonal CROD, **at any hour**, and water is on order to supply that capacity, the United States is obliged to make the power resource available (that is, put the generator units on-line and release the water through them).

MWD is a water and power utility service district which serves a significant portion of southern California. MWD is a recognized utility monopoly regulated by the State of California and has a perpetual contract right to 50 percent of electric power generated at Parker Dam.

Reclamation has the discretion to ask the Secretary of Energy to ask the electric service customers to renegotiate their contracts. Presently, the funding source for operation, maintenance, and replacement (OM&R) for the dams and powerplants and for WAPA's associated marketing expenses is supplied through Federal appropriations. These appropriations are then repaid to the Federal Treasury from power sale revenues. Beginning in fiscal year 1998, there will be an administrative modification to this system; Federal funds will no longer be made available for this purpose. Instead, the power contractors will provide funding at the beginning of each fiscal year to cover OM&R and WAPA's marketing expenses. This expense will be repaid throughout the fiscal year by power customers receiving credits on their power supply statements.

Hoover Dam (Boulder Canyon Project):

Each electric service contract for Hoover Powerplant electric service was executed on behalf of the United States by WAPA. Reclamation has signed in concurrence.

Subparagraph 5.1.2.2 in each contract states in part:

> "Western shall be obligated to provide regulation, ramping and spinning reserves to the Contractor in quantities that can be provided by Hoover Powerplant, except as provided in paragraph 5.6.2; **Provided**, that Western may provide regulation, ramping and spinning reserves from other Federal Projects on the Colorado River if such regulation, ramping and spinning reserves can be made available from such other projects in the same quantity and quality as if such regulation, ramping and spinning reserves were provided by Hoover Powerplant, subject to the limitations of paragraph 5.6.2."

The limitation referenced in paragraph 5.6.2 deals with powerplant equipment emergencies. Reclamation has concurred with this subparagraph.

The use of a "dynamic signal" means that each contractor can request its contractual power entitlement on a 4-second interval, which is the industry standard time step required by the Western Systems Coordination Council (WSCC). Reclamation is a fully participatory WSCC member and is obligated to follow the guidelines declared by the WSCC.

43 CFR Part 431:

The "General Regulations for Power Generation, Operation, Maintenance, and Replacement at the Boulder Canyon Project, Arizona/Nevada," are provided in 43 CFR Part 431. Although Reclamation cannot violate this or any CFR, such CFR's are subject to revision. The following authorities provided the legal basis for 43 CFR Part 431:

- Reclamation Act of 1902 (32 Stat. 388),

- Boulder Canyon Project Act of 1928 (43 U.S.C. 617 *et seq.*),

- Boulder Canyon Project Adjustment Act of 1940 (43 U.S.C. 618 *et seq.*),

- Colorado River Storage Project Act of 1956 (43 U.S.C. 620 *et seq.*),

- Colorado River Basin Project Act of 1968 (43 U.S.C. 1501 *et seq.*), and

- Hoover Power Plant Act of 1984 (98 Stat. 1333).

The following definitions are included in § 431.3:

> *Colorado River Dam Fund or Fund* shall mean that special fund established by section 2 of the Project Act and which is to be used only for the purposes specified in the Project Act, the Adjustment Act, the Colorado River Basin Project Act, and the Hoover Power Plant Act.
>
> *Contractor* shall mean any entity which has a fully executed contract with WAPA for electric service pursuant to the Hoover Power Plant Act.
>
> *Project or Boulder Canyon Project* shall mean all works authorized by the Project Act, the Hoover Power Plant Act, and any future additions authorized by Congress, to be constructed and owned by the United States, but exclusive of the main canal and appurtenances authorized by the Project Act, now known as the All-American Canal.
>
> *Replacements* shall mean such work, materials, equipment, or facilities as determined by the United States to be necessary to keep the Project in good operating condition, but shall not include (except where used in conjunction with the word "emergency" or the phrase "however necessitated") work, materials, equipment, or facilities made necessary by any act of God, or of the public enemy, or by any major catastrophe.

The operational requirements needed to satisfy 43 CFR Part 431 is non-discretionary.

Power generation responsibilities are discussed in § 431.4, which states in pertinent part:

> "Reclamation shall release water and make available generating capacity and generated energy in such quantities and at such times as are necessary for the delivery of the capacity and energy to which the contractors are entitled."

The administration and management of the Colorado River Dam Fund is found in § 431.7, which states in pertinent part:

"Reclamation is responsible for the repayment of the Project and the administration of the Colorado River Dam Fund and the Lower basin Development Fund.

(a) All receipts to the Project shall be deposited in the Fund along with electric service revenues deposited by Western and shall be made available without further appropriation for:

(1) Defraying the costs of operation (including purchase of supplementary energy to meet temporary deficiencies in firm energy which the Secretary of Energy is obligated by contract to supply), maintenance and replacement of all Project facilities, including energy replacement necessary to assure continuous operations."

Since these receipts are the major source of funding for the operation and maintenance of the Boulder Canyon Project, the operational requirements needed to generate these receipts and revenues are non-discretionary.

The Hoover Power Plant Act of 1984:

Section 106 of this act authorized the reimbursement of funds advanced by non-Federal purchasers for the uprating program as a repayment requirement of the Boulder Canyon Project. The non-Federal entities provided the United States with $165 million in up-front funding to implement a major construction program to increase generation capacity at Hoover Powerplant. The methodology for the repayment of the funds is described in 10 CFR Part 904.12 which reads:

"(a) Funds advanced to the Secretary for the Uprating Program and costs reasonably incurred by the Contractor in advancing such funds, as approved by Western, shall be returned to the Contractor advancing the funds during the contract period through credits on that contractor's power bills. Appropriate credits will be developed and applied pursuant to the terms and conditions agreed to by contract or agreement.

"(b) All other obligations of the United States to return funds to a Contractor shall be repaid to such Contractor through credits on power bills, with or without interest, pursuant to terms and conditions agreed to by contract or agreement."

This act requires the United States to use electric service credits paid over a 50-year period to repay the $165 million in up-front funds provided by the power contractors. The additional generating capacity provided by these funds would need to be optimized to produce the revenue required to repay this obligation.

7. Channel Maintenance and Levee System

The Colorado River Front Work and Levee System (CRFWLS) Act of 1946 (as amended) provides that for the purposes of controlling the floods, improving navigation, and improving the flow of the Colorado River, Reclamation will (i) operate and maintain the CRFWLS in Arizona, Nevada and California, (ii) construct, improve, extend, operate and maintain protection and drainage works and systems, (iii) control said river, and improve, modify, straighten, and rectify the channel thereof, and (iv) conduct investigations and studies in connection therewith.

Although these directions and responsibilities are relatively explicit as to what must be done, the details of the works, and the "how" and "when" parameters, are left to the discretion of the Secretary and Reclamation. The channel maintenance and levee system processes are considered discretionary for the Secretary and are covered within this assessment and consultation.

8. Yuma Desalting Plant and 5-Mile Zone

The Yuma Desalting Plant (YDP), completed in 1992 and located about 6 miles west of Yuma, Arizona, was constructed to enable the United States to comply with its water quality obligations under Minute No. 242, an extension of the 1944 Treaty with Mexico. Non-discretionary operation of the YDP to meet the salinity requirement of the water delivered to Mexico is not anticipated during the 5-year temporal scope of this assessment. Instead, this assessment addresses discretionary one-third operation of the YDP. Discretionary operation of the YDP at one-third capacity may occur to market approximately 26,200 acre-feet of the 110,000-132,000 acre feet of water currently discharged annually to the Cienega de Santa Clara (Cienega), a marsh complex located in Sonora, Mexico, near the Sea of Cortez.

The one-third operation is addressed programmatically in this assessment because a specific plan and agreement for marketing the desalinated water have not been completed at this time. An Environmental Impact Statement (EIS) was completed in 1975 for implementing Title I of the Salinity Control Act which includes the YDP. All mitigation measures identified during the development of the EIS have been completed. However, operation of the YDP for any purpose has international involvement and potential environmental impacts in Mexico. Therefore, startup and operation of the YDP for water marketing will be negotiated with Mexico by IBWC, the Federal agency responsible for ensuring that all treaties and agreements between the United States and Mexico are honored, including environmental agreements such as the North American Agreement on Environmental Cooperation.

The 5-mile zone is a 36,000-acre area 10 miles south of Yuma, Arizona, containing Reclamation-acquired and other lands needed to construct, operate, and maintain a well field providing water to Mexico in partial fulfillment of the 1944 Treaty with Mexico and as required by Title I of the Salinity Control Act. Reclamation's discretionary activities in the zone are limited to maintaining the 21 wells in the well field, the associated delivery canal, and the YDP sludge disposal site.

9. Endangered Species Conservation Activities

Reclamation has discretion to conduct activities benefitting threatened and endangered species under section 7(a)(1) of the ESA. Under the Act, Reclamation and other Federal agencies are permitted to:

> "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act".

In addition to aiding the recovery of listed species, Reclamation's endangered species program also has, as an objective, the conservation of non-listed species of concern to prevent their future listing.

C. Lower Colorado River Operation and Maintenance Procedures

1. Flood Control

Flood control was specified as a primary project purpose by the Boulder Canyon Project Act, the act authorizing Hoover Dam. The COE is responsible for developing the flood control operation plan for Hoover Dam and Lake Mead as indicated in 43 CFR 208.11. The plan is the result of a coordinated effort by the COE and Reclamation, but the COE is responsible for providing the flood control regulations and has authority for final approval. Any deviations from the flood control operating instructions must be authorized by the COE and the Secretary is responsible for operating Hoover Dam in accordance with these regulations. Flood control regulations for Lake Mead were established to deal with two distinct types of flooding: rain and snowmelt. Snowmelt constitutes about 70 percent of the annual runoff of the Colorado River into Lake Mead.

Lake Mead's uppermost 1.5 maf of storage capacity, between elevations 1219.6 and 1229.0, is allocated exclusively to control floods from rain events. Within this capacity allocation, 1.218 maf of flood storage is above elevation 1221.4, which is the top of the raised spillway gates.

Flood Control regulations specify that once flood releases exceed 40,000 cfs, the releases shall be maintained at the highest rate until the reservoir drops to elevation 1221.4 msl. Releases may then be gradually reduced to 40,000 cfs until the prescribed seasonal storage space is available.

The flood control regulations set forth two primary criteria to deal with snowmelt:

1) preparatory reservoir space requirements, and 2) application of runoff forecasts to determine releases.

In preparation for the coming year's season of snow accumulation and associated runoff, progressive expansion of total Colorado River system reservoir space is required during the latter half of each year. Minimum available flood control space increases from 1.5 maf on August 1 to 5.35 maf on January 1. Required flood storage space can be located within Lake Mead and in specified upstream projects: Lakes Powell and Navajo, and Blue Mesa, Flaming Gorge and Fontenelle Reservoirs. Minimum Lake Mead space required for exclusive flood control is 1.5 maf. The following chart shows the amount of required flood storage space by date:

Minimum Required System Space

Date	Amount in acre-feet
August 1	1,500,000
September 1	2,270,000
October 1	3,040,000
November 1	3,810,000
December 1	4,580,000
January 1	5,350,000

Normal space-building releases from Lake Mead to meet the required August 1 to January 1 flood control space are limited to a maximum of 28,000 cfs. Releases based on the water entitlement holders' demand are much less than 28,000 cfs.

Between January 1 and July 31, flood releases, based on forecasted inflow, may be required to prevent filling of Lake Mead beyond its 1.5 maf minimum space. Starting on January 1, the Colorado River Forecasting Service issues runoff forecasts each month through July 31. The release schedule contained in the COE regulations is based on increasing releases in six steps (shown in the following chart):

Flood Control Releases at Hoover Dam

Step	Amount in cubic feet/second
Step 1	0
Step 2	19,000
Step 3	28,000
Step 4	35,000
Step 5	40,000
Step 6	73,000

The lowest step, zero cfs, corresponds to times when the regulations do not require flood control releases. Hoover Dam releases are then made on water and power objectives. The second step, 19,000 cfs, is based on the Powerplant capacity of Parker Dam. The next step, 28,000 cfs, is the approximate maximum release that will not cause damage through the Parker Strip and corresponds to the Davis Dam Powerplant capacity which is 28,000 cfs. The fourth step in the COE releases is 35,000 cfs, which corresponds to the Powerplant capacity of Hoover Dam in 1987. The present Powerplant capacity at Hoover Dam is 49,000 cfs. At the time Hoover Dam was completed, 40,000 cfs was the approximate maximum nondamaging flow downstream from the dam. In addition the "Colorado River Floodway Act" requires that the minimum flood release from Hoover Dam can be no less than 40,000 cfs plus tributary flows. Prior flood control plans regulated outflow to 40,000 cfs, which forms the fifth step. Releases of 40,000 cfs and greater would result from unusually large floods. The sixth and last step in the series, 73,000 cfs, is the maximum controlled release from Hoover Dam without spillway flow.

Runoff forecasts are received from the Colorado River Forecast Service in Salt Lake City, Utah. Flood control releases are required when forecasted inflow exceeds available storage space at Lakes Mead and Powell and allowable space in other upper basin reservoirs. This includes accounting for projected bank storage and evaporation losses at both lakes, plus net withdrawal from Lake Mead by the Southern Nevada Water Project. The COE regulations set the procedures for releasing the volume that cannot be impounded.

Average monthly releases are determined early in each month and apply only to the current month. The releases are progressively revised in response to updated runoff forecasts and changing reservoir storage levels during each subsequent month throughout the January 1 - July 31 runoff period. If the reservoirs are full, drawdown is accomplished to vacate flood control space as required. Unless flood control is necessary, Hoover Dam is operated to meet established downstream water requirements.

Lake Mead end-of-month elevations are driven by downstream demands, Glen Canyon releases, and Mexican Water Treaty deliveries to Mexico. Lake Mead end-of-month target elevations are not set as are Lake Mohave and Lake Havasu. Normally, Lake Mead elevations rise into March and decline with increasing irrigation deliveries through June or later and then begin to rise again. Lake Mead's storage capacity provides for the majority of Colorado River regulation from Glen Canyon Dam to the border with Mexico.

Due to the amount of vacant storage in the Colorado River reservoirs, no flood control releases are anticipated in 1996. For purposes of providing insight into annual flood and drought cycles on the lower Colorado River, Figures 6 and 7 provide an historical summary of annual flows at Lees Ferry and below the Hoover Dam site, for the pre- and post-construction periods of Glen Canyon and Hoover Dams. For the same purpose, the yearly high and low water elevations for Lake Mead are illustrated in Figure 8.

Annual water deliveries may be reduced if a drought on the Colorado River system occurs. If a surplus year is declared on the Colorado River system, flows will be adjusted to meet water entitlement holders' demands and to drain system storage.

2. Annual Operating Plan

Each year, Reclamation consults with the lower basin States, the Indian Tribes, and Colorado River water users regarding water conservation and the use of Colorado River water. Reclamation's authority for such activities is found in section 602 of the Colorado River Basin Project Act of September 30, 1968. Reclamation also may review specific uses under 43 CFR 417 which provides the authority for Reclamation to conduct consultations with each public or private organization that is entitled to Colorado River water. Water users are contacted by Reclamation to discuss water needs and are requested to furnish monthly estimates for the upcoming year. The purposes of the consultations are to make annual recommendations relating to water conservation measures and operating practices in the use of Colorado River water and to determine if estimated water requirements for the next year will exceed reasonable beneficial use.

All of the information gathered is used to develop an Annual Operating Plan (AOP) as required by the Colorado River Basin Project Act, after taking into consideration probable runoff, depletions, and consumptive uses. The AOP is formulated for the upcoming year under a variety of possible conditions. The plan is developed based on projected requirements, existing storage conditions, and probable inflows. It is prepared by Reclamation, acting on behalf of the Secretary, in cooperation with the seven basin States, other Federal agencies, Indian Tribes, State and local agencies, and the general public, including environmental interests.

The AOP is designed to govern the general operation of the river system on a seasonal and annual basis and specifies, as an objective, the minimum amount of water to be released from Lake Powell through Glen Canyon Dam for the year. For the lower basin, the AOP determines whether demands will be met according to shortage, surplus, or normal water year supply conditions. A forecast of water supply, reported water use to date, and projected water use for the year is produced monthly as the information becomes available to Reclamation. The 24-month study, discussed later in this section, provides the monthly updates and projected reservoir conditions throughout the lower basin for the following 2 years.

Prior to the beginning of the calendar year, diversion schedules are requested from water users entitled to Colorado

River water. These schedules are of estimated monthly diversions, which allows Reclamation to determine a tentative schedule of monthly releases through the Hoover Powerplant. Actual monthly releases are determined by the demand for water downstream of Hoover Dam. Daily changes in water orders are made to accommodate emergencies, rainstorms, changes in wind, holidays, and various other parameters. Appendix E provides additional information on reservoir releases and elevations for non-flood release years during 1980-1995 and projected releases from 1996-2010.

3. Operation of the Colorado River Below Davis and Parker Dams

The scheduling and subsequent release of water through Davis and Parker Dams effect daily fluctuations (going through its changes in a day, a day being 24 hours) in river flows, depths, and water surface elevations downstream of these structures. Since such releases may affect downstream critical habitat reaches, typical seasonal flow patterns are illustrated for representative gauging locations on the lower Colorado River (Figures 9,10,11,12,13). The location of the representative gauging stations are shown on Figure 2a and their names and distance (in miles) from the SIB are: Davis Dam, 275.4; Parker Dam, 192.2; Water Wheel, 152; Taylor Ferry, 106.6; and below Cibola Valley, 87.3. Typical seasonal flows (in cfs) and water surface elevations (in feet msl) are shown for each of the five stations. Variations in water depths are illustrated for representative stations in Appendix E.

Figures 9 and 10 demonstrate that the water surface elevation fluctuates most noticeably in the river reaches closest to the dams. Those fluctuations become more and more attenuated as the distance downstream increases, as shown in Figures 12 and 13. The Mohave Valley and Parker Divisions of the river are most affected by fluctuations on a daily basis. The Imperial, Laguna and Yuma Divisions are the least affected. The river fluctuates seasonally with the highest water levels occurring during the summer and the lowest water levels occurring during the late fall and winter, except during flood releases. The current ecosystem on the river is, in part, a result of these daily and seasonal fluctuations.

Under normal operating conditions, Reclamation's Yuma Area Office (YAO) receives daily water orders for those water entitlement holders within the United States and Mexico below Parker Dam. Water orders are totaled and submitted to Hoover Dam personnel who then coordinate releases to meet downstream water demand and power demands from Parker, Davis, and Hoover Dams.

Mexico submits each Wednesday a daily water order, to cover the following week, through IBWC at Yuma; however, Mexico cannot change its daily water order once it is received, except in the case of an emergency. United States water entitlement holders below Parker Dam also furnish their water orders to YAO each Wednesday; however, United States water entitlement holders may modify their master schedule of water orders at least 3 days in advance of water releases from Parker Dam, and they may also vary from their master schedule on a daily basis if necessary. Release requirements from Parker Dam are equal to the water required by Mexico and United States users downstream of Parker Dam and system losses resulting from transporting the water from Parker Dam to Imperial Dam.

When either more or less water than needed by United States entitlement holders arrives at Imperial Dam, storage behind Imperial Dam, Laguna Dam, and Senator Wash Dam is utilized to attempt to regulate incoming Colorado River flows in order to meet actual water demand and prevent over deliveries of water to Mexico. Regulating flows involve either pumping water into storage if more water arrives than is demanded or releasing water into the river when there is not enough to meet demands. Changes to water demand may result from a change in weather (rainfall, frost warnings, wind, high temperatures, cooler temperatures, etc.), holidays, or structural failure of an irrigation facility.

Normal operational variances in elevation at Imperial Dam are from 180 feet to 180.9 feet msl. The top of the spillway at Imperial Dam is approximately 181 feet; this elevation is seldom exceeded. If water demand exceeds flows arriving at Imperial Dam for extended periods, the elevation behind Imperial Dam may, on very rare occasions (1 to 3 times per year), be drawn down to elevation 178.5 feet. This elevation would not be maintained for more than a few days. Elevations of the reservoir above Imperial Dam continuously fluctuate, to some degree, daily and during the day. Fluctuations are due to variability in the flows arriving at the dam and water entitlement holders' demand changes.

Normal operational variances in elevation at Laguna Dam are from 138 feet to 151.3 feet msl. The top of the spillway at Laguna Dam is elevation 151.3 feet msl. The maximum elevation is met a few times a year when the storage is used to prevent or reduce over deliveries to Mexico. The lower elevations occur when it is necessary to use the water stored in Laguna Reservoir to meet Mexico's water order. This normally occurs when water demand has increased after releases have already been made from Parker Dam. Elevations behind Laguna Dam continuously change due to the continuously changing water demand at Imperial Dam.

Normal operational variances in elevation at Senator Wash reservoir are from 210 feet to 240 feet msl. The reservoir is currently on an elevation restriction at 240 feet msl for safety concerns regarding seepage above that level. Prior to the elevation restriction of 240 feet msl, the normal range in elevation was from 210 feet to 251 feet msl (the top of the spillway). Several potential repairs for Senator Wash which could allow full utilization of its storage capacity are under current review, but it will be a number of years before repairs can be accomplished. The reservoir elevation is continually fluctuating because Senator Wash is used to regulate flows arriving at Imperial Dam.

Flows arriving at Imperial Dam normally range from a high of about 14,400 cfs (which usually occurs in late spring to summer) to a low of about 2,500 cfs (which usually only occurs after a heavy local rainfall over the entire area below Imperial Dam, usually November or December, and when water entitlement holders are not taking water). Mexico's water order has to be delivered regardless of excess rainfall.

Flows below Laguna Dam usually range between 300 and 500 cfs. Occasionally flows may range up to 4,000 cfs or higher if a heavy rainfall has occurred.

Flows below Imperial Dam into the Colorado River Channel (California Sluiceway) normally range from about 250 cfs to about 350 cfs and are made up principally of return flows from the All-American desilting basins and gate leakage from the California sluiceway gates at Imperial Dam.

Sluicing flows are released to remove sediment accumulated from the desilting basins in the sluiceway channel. These sluicing flows usually occur 2 to 3 times a month and consist of flows ranging from 8,000 to 10,000 cfs which are released for periods of about 20 minutes. These flows carry sediment to the Laguna Desilting Basin located about 2 miles downstream from Imperial Dam.

4. Water Delivery Requirements to Mexico in Accordance with the Mexican Water Treaty of 1944

Mexico is entitled to receive a total of 1.5 maf of water delivered at the NIB and SIB each year- of which at least 1.36 maf are to bedelivered via the Colorado River (normally consisting of releases from Colorado River system storage and drainage returns) to the NIB; up to 140,000 acre-feet of Colorado River water (normally consisting of drainage returns and wasteway flows) can be delivered at the SIB. In the event a surplus year is declared by the Secretary, Mexico may increase its annual water order by 200,000 acre-feet to a total of 1.7 maf. In the event of a declared shortage, water deliveries to Mexico would be reduced in the same proportion as consumptive uses in the United States are reduced.

In December of each year, Mexico provides the United States with an advance monthly water order for the following year. This water order can only be changed by providing the United States 30 days' advance notice, and each monthly water order can be increased or decreased by no more than 20 percent of the original monthly water order. The treaty further stipulates that Mexico's total water order must be no less than 900 cfs and no more than 5,500 cfs during the months of January, February, October, November, and December. During the remainder of the year, Mexico's water order must be no less than 1,500 cfs and no more than 5,500 cfs. Daily water orders are usually not allowed to increase or decrease by more than 500 cfs.

Minute 242 defines the salinity requirements of Colorado River water delivered to Mexico. A salinity monitoring program is conducted at points below Parker Dam to the NIB. Computations are made projecting the annual salinity requirements from these data. If necessary, actions are taken to reduce salinity, such as reducing drainage pumping, or operating the YDP. Operating the YDP for salinity control is not expected to occur within the next 5 years.

5. Process for Daily Water Requirements and Hourly Release Schedule

The daily and hourly water release target process is set by collecting data in the reaches between Hoover, Davis, and Parker Powerplants as well as the SIB. The availability of water is determined by the 24-month study which is updated on a monthly basis. The 24-month study is compiled from present snow pack water content, reservoir storage, projections from water users for the current year and projections from historical data forecasting. The availability of generating units to deliver the required downstream flows is coordinated with the projected 24-month study and the 18-month unit outage estimate. The 18-month estimated individual unit maintenance schedule incorporates monthly water delivery needs, the contractual requirement of WAPA's electric service customers, and required generator maintenance work. The annual 18-month unit outage schedule is updated on a monthly basis if changes are required.

a. Parker Dam to Mexico

The first reach from the SIB extends up river to Parker Dam, located at Parker, California, and is under the jurisdiction of YAO. YAO collects data from Mexico, the All-American Canal users, the Gila Gravity Main Canal users, North Gila Canal, various Indian Tribes, PVID reservoirs, etc. These data are combined and sent to the water scheduling office located at the Hoover Dam facility. The lower Colorado River dam's schedulers profile hourly releases using the electric service customer's energy load profiles. Water from Parker Dam has a 3-day travel time to Imperial Dam, a major diversion point for irrigation. Elevated water releases on Saturday and Sunday, when power is in less demand and revenue is less, will arrive at Imperial Dam on Tuesday and Wednesday, workdays for the growers. Conversely, low releases on Wednesday and Thursday (when power has a higher "weekday" value) will arrive at Imperial Dam on Saturday and Sunday, not typically workdays for the growers. These profiles are coordinated with WAPA's power schedulers in Phoenix, Arizona, and the control room operators located at Hoover Dam. The "Parker Schedule Today," Figure 14a, is an example of the hourly projected release schedule. Between 2 p.m. and 3 p.m. the current day's schedule is revised and the next day's schedule is set by Hoover water operations schedulers to meet the daily required downstream water release and to incorporate any changes. The control room operator normally fine tunes the hourly release flows (see hand-marked changes) between the hours of 8 p.m. and 12 midnight daily to stay within plus or minus 40 cfs of the total scheduled downstream requirement. The "Parker Actual Release," Figure 14b, shows actual historical hourly release data for the Parker Dam facility. The Parker generating units are not normally placed on dynamic control (dynamic control causes the units to fluctuate on a 4-second interval), which would subject them to unscheduled river flow changes, which minimizes hourly downstream fluctuations. The hourly flow changes begin at 10 minutes to the hour and are fully implemented 10 minutes after the hour. These flow changes are computer controlled, and varying rates of unit releases over time can be changed.

b. Parker Dam to Davis Dam

The second reach starts at the Parker Dam facility and goes upstream to the Davis Dam facility. Water schedulers collect data from CAP, MWD, and others who divert from this reach of the river. These data are added to the Parker Dam facility's total scheduled plant water releases, and while considering flood control reservoir elevation on Lake Havasu, the total daily water releases are calculated for Davis Dam. The flood control reservoir elevation requirements for Lake Havasu are shown in Figure 15. The hourly release profile is determined by electric service customer requirements, the current downstream river needs, and upstream Lake Mohave requirements. Between 2 p.m. and 3 p.m. the current day's schedule is revised and the next day's schedule is set by schedulers to meet the daily required downstream water releases and incorporate any daily changes. The control room operator, located at Hoover Dam, normally fine tunes the hourly release flows between the hours of 8 p.m. and 12 midnight daily to stay within plus or minus 300 cfs of the total scheduled downstream requirement.

c. Davis Dam to Hoover Dam

The third reach starts at Davis Dam and goes upstream to Hoover Dam. Reclamation combines the total estimated daily water release requirement of Davis Dam and the target Lake Mohave elevation to determine monthly the amount of water required downstream of Hoover Dam. This monthly release is formulated into a monthly energy figure. The monthly energy figure is sent to WAPA and the estimated daily energy schedule is set by its power scheduling personnel. The Hoover Dam generators are set on Automatic Generation Control (AGC) which follows the power system's actual dynamic demands (See Figure 16, Typical Dynamic Power Generation). This graph represents the dynamic energy changes for each hour. The actual downstream water flow releases follow these patterns exactly. These monthly water and power figures are monitored by the scheduler. If the Lake Mohave elevation approaches the set high/low constraints, the scheduler coordinates with WAPA's power scheduler in setting a new energy target if necessary (See Figure 17, Lake Mohave Operational Constraints graph).

The Lake Mohave operational constraints are not to drop the lake's elevation more than 2 feet in any 10-day period between February and April. During this time period, energy is targeted for a 10-day period. The lake's elevation is not allowed to drop below 640 feet msl between April and the end of July and remains above elevation 637 feet msl until after September 16th. These voluntary constraints (represented by curve A in Figure 17) are for a 5-year period ending in 1998 and are to accommodate the Razorback Sucker Program. After this 5-year period, the future operations of Lake Mohave will revert to the pattern shown on curve B in Figure 17.

d. Seasonal Release Patterns

There are four seasonal release patterns for the three facilities - Hoover Dam, Davis Dam, and Parker Dam. Figures 18, 19, and 20, respectively, show the Hoover, Davis and Parker Dams' normal hourly release pattern for a representative day in each of the four seasons. The curves show a flatter water release for Parker Dam than for Davis Dam; with Hoover Dam releases taking most of the fluctuations. This is due to the fact that Hoover Dam normally releases water directly into Lake Mohave, which serves to stabilize river fluctuations. Hoover Dam is used to respond to power system fluctuations because it responds quicker, more efficiently, and with the least disturbance to the river system.

6. River Maintenance

Under the authority of the CRFWLS Act of March 3, 1925, as amended, Reclamation maintains the channel, banklines, levee systems, and control structures along the lower Colorado River. This includes 168 miles of stabilized banklines, 114 miles of levees and 75 associated river structures including jetties and training structures. For administrative purposes the reaches of the river from Davis Dam to the SIB are divided into maintenance divisions, which are roughly determined by different physical characteristics as identified in Figure 2. A description of each division is presented in Appendix C.

The routine maintenance on existing stabilized banklines consists of placing riprap on bankline areas where the existing riprap has eroded or otherwise needs repair. Other routine maintenance involving riprap includes repair of jetties and training structures. Again, this repair consists of replacing riprap where it has eroded or otherwise needs replacing. Some riprap is needed occasionally for repair of levee armoring.

Associated with the maintenance of the banklines, levees, and river control structures is maintenance of access and bankline roads. Roads are maintained on the levees and adjacent areas to stabilize banklines. The maintenance is routine road repair required for gravel roads. While these roads are also used by the public for various reasons, the roads are maintained for operation and maintenance of Reclamation project facilities and are not maintained up to public road standards.

Riprap and gravel for the above maintenance activities are obtained from various stockpile sites located along the river if the work is conducted by Reclamation personnel. As a rule, quarrying activities are conducted to produce and maintain stockpiles of rock and gravel along the river for emergency flood control purposes and routine maintenance described above. In general, quarrying and hauling activities are contracted when it is determined the stockpiles need to be replenished. This replenishment could be necessary after a long period of time if the stockpiles are used only for routine maintenance, or after a short period of time if a high-flow emergency occurs. In some cases, if extensive repairs are required to stabilize banklines, levees, and river control structures, the work is contracted to private enterprise. In many of those cases, quarrying activities occur and the riprap and gravel are hauled directly from the quarry.

Reclamation routinely dredges two types of areas: sedimentation basins and backwaters. Reclamation maintains two dredging basins -the Topock Dredge Basin located near Needles, California, and the Laguna Dredge Basin, located between Imperial and Laguna Dams. In addition, Reclamation routinely dredges material from the headworks of the All-American Canal and the Gila Gravity Main Canal at Imperial Reservoir. These dredging operations are confined to the areas mentioned above. The dredging uses a hydraulic dredge, and the material is deposited on spoil areas proximate to the dredging basins. In the case of the headworks of the All-American Canal and the Gila Gravity Main Canal, the dredged material is deposited into the California Sluiceway below Imperial Dam and sluiced to the Laguna Dredge Basin for removal.

Reclamation also conducts dredging operations for mitigation maintenance on backwaters which have been identified for maintenance to restore their fish and wildlife functions. In addition, Reclamation will cost share enhancement dredging for other backwater wetlands along the lower Colorado River. Reclamation conducts separate ESA consultations for those mitigation and enhancement projects. While those projects could be a routine part of Reclamation activities, the scope of the projects generally warrants separate ESA and National Environmental Policy Act (NEPA) compliance.

7. Yuma Desalting Plant and 5-Mile Zone

The YDP, completed in 1992 and located about 6 miles west of Yuma, Arizona, was constructed to enable the United States to comply with its water quality obligations under Minute No. 242, an extension of the 1944 Treaty with Mexico. The YDP is currently maintained in ready-reserve to enable future activation if required.

The 5-mile zone is a 36,000-acre area 10 miles south of Yuma, Arizona, containing Reclamation-acquired and other lands needed to construct, operate, and maintain a well field to provide water to Mexico in partial fulfillment of the 1944 Treaty and as required by Title I of the Salinity Control Act. Reclamation maintains the 21 wells in the well field, the associated delivery canal, and the YDP sludge disposal site. A description of the operation and maintenance of the YDP and 5-mile zone is provided in Appendix F.

D. Endangered Species Conservation Program

1. Introduction

In addition to the previously described Colorado River operation and maintenance activities, Reclamation also has an ongoing program of endangered species conservation. These activities are authorized and executed pursuant to section 7(a)(1) of the ESA. The activities range from being very specific in nature to the broad multi-species conservation program (Appendix A). Reclamation's endangered species conservation activities, that are currently underway or that are anticipated to occur within the next 5 years, are described below.

2. Endangered Razorback Sucker and Bonytail Conservation

Reclamation has an active program for the conservation and recovery of endangered razorback suckers and bonytail. These activities are being done under section 7(a)(1) of the ESA and are part of our current routine operation of the lower Colorado River. As part of the lower Colorado River MSCP interim conservation effort, Federal and State biologists met in July of 1995 to prioritize and quantify recovery and conservation program needs for endangered fish and other species during the 1995-2005 period (Appendix G). The specific immediate needs for razorback sucker and bonytail are summarized as follows:

- Razorback Sucker (by year 2000)
add 50,000 adults to Lake Mohave
add 25,000 adults to Lake Havasu

- Bonytail (by year 2005)
add 25,000 adults to Lake Mohave
add 25,000 adults to Lake Havasu

These needs encompass and include the goals of the Native Fish Work Group (NFWG) and Lake Havasu Fishery Improvement Project (HAVFISH) described below.

Reclamation is committed to providing the resources necessary to achieve at least half, if not more, of the quantified goals for the two species. The programs described below represent some of the ways this is currently being or will be achieved.

a. Native Fish Work Group

The NFWG on Lake Mohave was formed in 1989 as an initiative of Reclamation biologists Gordon Mueller and Tom Burke. In addition to Reclamation, the original member agencies were Nevada Division of Wildlife (NDOW), Arizona Game and Fish Department (AGFD), FWS, NPS [Lake Mead National Recreation Area (LMNRA)], and Arizona State University (ASU). The primary purpose of the NFWG was to replace the aging population of adult razorback suckers resident to Lake Mohave. Replacing the sunset population of razorback suckers with immature fish spawned by Lake Mohave's wild population will maintain the population's genetic diversity and viability.

For many years, biologists observed adult razorback suckers coming into shoreline areas on Lake Mohave to spawn. While larvae were produced from these efforts, recruitment into the adult life stage was not occurring. Minckley (1983) documented a pattern of disappearance of razorback sucker from Colorado River basin reservoirs 40-50 years after initial impoundment. Studies conducted on adult razorback suckers from Lake Mohave during the mid-1980s showed the fish to be 24-44 years old and predicted the collapse of the Lake Mohave population by the turn of the century (McCarthy and Minckley 1987).

Experiments were conducted at Yuma Cove on Lake Mohave in 1985-87, wherein adult razorback suckers were removed from spawning grounds and placed into a predator-free lakeside pond, Yuma Cove, which produced young suckers of a size larger than found in the lake proper (Marsh and Langhorst, 1988). At that time, Yuma Cove was separated from the main lake by a low, natural berm comprised of wave-washed sand and gravel. This berm was breached by wave action in 1985, and predatory fishes from the lake accessed the backwater pond. When the berm again breached in 1987, the project was terminated.

The first action taken by the NFWG was to rebuild the sand and gravel berm at Yuma Cove to a more secure level. The group then removed all fishes from the pond with an ichthyocide and then stocked it with ripe adult razorback suckers. The first success was in 1992 when 150 young fish were reared to over 10 inches in length and released to the lake. In 1993 the NFWG expanded its activities to other lakeside ponds and reared some 500 fish for release into Lake Mohave. In 1994 NFWG started focusing on using younger life stages by collecting 10,000 wild larvae from spawning areas around the lake and placing them into the lakeside ponds. This resulted in over 2,200 young fish being reared and released to Lake Mohave. The effort increased in 1995 with almost 20,000 larvae being captured. Of these, half were stocked in lakeside ponds for rearing to release-size during that year and half went to Willow Beach National Fish Hatchery (WBNFH) for rearing to juvenile stages to then be stocked into lakeside rearing ponds in January 1996. The 1995 results were similar to 1994 (except that the fish were larger at time of release), with some 2,000 fish being reared and released to the reservoir. Over 100 of these fish have been recaptured at spawning grounds during spring surveys, completing the cycle of recruitment to adulthood.

As a charter member and lead agency in the NFWG, Reclamation is committed to spending at least $250,000 per year on capturing "wild" razorback sucker larvae from Lake Mohave and providing for their rearing in predator-free environments on or near the lake.

The program was aided in 1996 by increased funding from Reclamation as part of its commitment to the MSCP (described earlier in this report). NFWG was able to capture over 60,000 wild razorback sucker larvae. These fish are presently rearing in either lakeside backwater ponds or in modified raceways at WBNFH. The NFWG has included rearing of bonytail in its program and has successfully reared and stocked almost 500 fish since 1994. Reclamation is committed to this program and its goal to replace the Lake Mohave population of adult razorback suckers.

b. Willow Beach National Fish Hatchery

Since 1994, Reclamation has been working with FWS at WBNFH to retrofit portions of this cold water facility in order to rear native warm-water fishes. In 1994, Reclamation engineers designed and installed heating systems for the hatch house for initial rearing of eggs and larvae. Approximately 8,000 young razorback suckers were produced and reared for stocking into rearing ponds at Lake Havasu. In 1995, the first of six paired outside raceways received solar-heated water in a closed circuit loop, providing a warm water rearing area for razorback suckers and bonytail. In 1996 and 1997, five more raceway units will be developed. Reclamation is also providing funds and staff for feeding and maintaining the fishes in these modified facilities. Reclamation is committed to this cooperative program with FWS to develop warm water rearing capabilities at Willow Beach. As part of the MSCP (also described below), Reclamation is providing staff support to Willow Beach through 1998 to accelerate the native fish rearing program.

c. HAVFISH Project

Reclamation is an active partner of the multi-agency, Lake Havasu Fishery Improvement Project, HAVFISH. One of the objectives of this multi-agency program is to release 25,000 razorback suckers and 25,000 bonytail into Lake Havasu over the next 10 years. Reclamation has provided technical and monetary support for this program since its beginning. As a full and active partner, Reclamation is committed to the goals of the program regarding native fish recovery and is working with FWS in the development of a native fish rearing facility on the CRIT reservation near Parker, Arizona.

d. Boulder City Golf Course Native Fish Rearing Project

Reclamation and NDOW signed an interagency agreement with the City of Boulder City to use the ponds at Boulder City Golf Course for rearing of native fishes. During 1994 the first lake on the course was drained and a new liner and aeration system were installed. In October 1994 approximately 1,400 juvenile razorback suckers (3-4 inches total length) were stocked into the pond. During 1995, over 400 of these suckers reached the target length of 10 inches and were stocked into Lake Havasu. During the 1996 spring spawning period, at least five of these fish were captured in Lake Mohave. This program is expanding with the development of three more ponds on the golf course, one each in 1996, 1997, and 1998.

e. Hualapai Native Fish Rearing Facility

Reclamation is providing technical and financial support to the Hualapai Tribe in northern Arizona for the development of a prototype native fish rearing facility. This facility may raise razorback suckers, bonytail, humpback chubs and other native fishes for reintroduction into the Colorado River and its tributaries within Grand Canyon and on tribal lands. The assessment of this potential project began in 1992 and is expected to continue.

3. Native Riparian Plant Restoration

Reclamation is committed to maintaining and expanding the cooperative native riparian plant restoration programs initiated along the lower Colorado River. These partnership activities include the establishment of native plant nurseries, demonstration plantings, enhancement projects, and research. Reclamation will commit at least $100,000 per year for the 5-year period covered by this document for native riparian plant restoration.

a. Native Riparian Plant Nurseries

Reclamation, in cooperation with FWS, has established three native riparian plant nurseries along the lower Colorado River. These nurseries have been established on Imperial National Wildlife Refuge, Cibola National Wildlife Refuge, and Havasu National Wildlife Refuge. In addition, Reclamation has established a fourth nursery in conjunction with the NPS at Lake Mead. Plant material from these nurseries can be utilized for restoration or enhancement projects by any of the cooperating agencies. Reclamation is committed to expanding these nurseries when desirable.

b. Demonstration Projects

Reclamation, also in cooperation with FWS, has established a series of demonstration areas along the lower Colorado River. As of 1996, 20 acres have been planted in 5 different plots. The main objective of this project is to study the biotic and abiotic factors influencing the survival and growth of native riparian species along the lower Colorado River. Reclamation is committed to the continuous monitoring of these sites and the establishment of future sites, contingent upon future funding levels and the signing of cooperative agreements with other agencies or groups.

c. Enhancement Projects

Reclamation and FWS have been involved in cooperative efforts to enhance native riparian habitat along the lower Colorado River. Approximately 200 acres will be revegetated between 1993 and 1998. Reclamation is committed to providing staff, materials, and/or funding to continue this effort, especially with wildlife refuges.

d. Research

Reclamation has entered into a cooperative agreement with the United States Department of Agriculture's (USDA) Agricultural Research Service to screen and select genotypes of four native riparian plant species for salinity tolerance. Clonal material from any genotypes exhibiting a higher degree of salinity tolerance will be stocked in nurseries along the lower Colorado River for use in future revegetation efforts. Reclamation has committed $100,000 annually for 2 years to conduct this project. Results are due in the fall of 1996.

4. Three-Finger Lake Project

In 1993, Reclamation and FWS began a cooperative project to restore Three-Finger Lake (Figure 21). Approximately 120 acres of channels and shallow backwater areas, plus one 20-acre native fish rearing pond, were dredged in 1995. The final phases of this project, including construction of the water intake system, the construction of protective levees and bankline structures, and the planting of native riparian vegetation will be completed by spring of 1997. The total of this cost-share project will be approximately $4 million. Reclamation has spent $2.5 million from 1995-96 on the Three-Finger Lake restoration project. The project will provide habitat for native fish and native (e.g., Yuma clapper rail) and migratory fauna such as the willow flycatcher.

5. Boulder City Wetland Project

The primary objective of the Boulder City Wetland Project is to demonstrate using reclaimed municipal wastewater to restore habitat for threatened and endangered species and species of concern. Secondary objectives include public education and research on improving water quality and restoring habitat for sensitive species. Reclamation's authority for the project piggybacks section 7(a)(1) of the ESA onto section 1605, Title 16 of the Reclamation Wastewater and Groundwater Study and Facilities Act (P.L. 102-575). The latter section provides Reclamation with the authority to construct and operate cooperative, cost-shared research and demonstration projects for reclaiming wastewater. The project is being cooperatively developed and funded by the City of Boulder City, Reclamation, NDOW, Clark County Conservation District, USDA Natural Resource Conservation Service, and National Biological Service. Reclamation's contribution towards the project will total $400,000 and will consist of in-house biological, geological, and engineering expertise and funding required for project construction.

The Boulder City Wetland will receive Colorado River water blended with treated wastewater from Boulder City's wastewater treatment plant. The blended wastewater will flow through a wetland system consisting of a ½-mile-long stream containing shallow marshes and pools, then through four 1-acre deep-water ponds (Figure 22). The stream and ponds will contain a variety of native wetland plants and be bordered by native riparian plantings. Water from the wetland will be used to irrigate turf at an adjacent Veterans Cemetery. In this manner, maximum benefit will be obtained from Boulder City's wastewater.

The variety of wetland and riparian habitats restored are being designed to maximize the number of species benefitting rather than focus on only a few species. Targeted species will include the southwestern willow flycatcher and several fishes such as razorback sucker and Moapa, Oasis Valley, and Pahranagat speckled dace. Habitat will also be restored for an insect species of concern: MacNeill's sootywing skipper.

Project planning was initiated in March 1995, and final designs for the project were completed in September 1995. Construction began in November 1995 and will be completed by November 1996. Following completion, a monitoring program will be initiated to evaluate the quality of the habitat restored and the success of establishing populations of sensitive species.

6. Lower Imperial Division Wetland Enhancement

This proposed cost-share project will restore and maintain streamflow of sufficient quality and quantity to enhance and assist in recovering and protecting riparian/wetland and aquatic fish and wildlife habitat. The proposed project extends from Imperial Dam upstream to Martinez Lake and encompasses a 9.5-mile reach of the lower Colorado River including about 3,000 acres of riparian habitat and wetlands and 22 backwater lakes (Figure 23).

The area is extensively used by waterfowl, neotropical birds, sport fish, amphibians, mammals, song birds, and other wildlife. This reach of the river is also heavily used by hunters, fishermen, campers, skiers, boaters, and jet skies. The life of the project is estimated to be 30 years.

The Interagency Backwater Subcommittee of the Lower Colorado River Work Group has identified and recommended this reach of river as a priority for restoration and enhancement. The subcommittee also recommended the formation of an ad hoc committee, consisting of representatives from the BLM, FWS, AGFD, California Department of Fish and Game (CFG), and Reclamation to organize and plan the restoration and enhancement project. The final plan should be completed by August 1996, and will include additional restoration and enhancement on the Imperial National Wildlife Refuge. Separate section 7 compliance has been completed for the Yuma clapper rail and razorback sucker but is needed for the southwestern willow flycatcher.

Project objectives for the California and Arizona sides of the river are as follows:

- Restore historical California channel (approximately 3 miles in length).

The existing channel has been silted in by recent floods, and cattails have become over abundant, plugging the channel. Unless the channel is restored to historical conditions, many of the backwaters and wetlands dependent on water flowing through the channel will become eutrophic and dried out.

Reclamation plans to dredge the channel approximately 30 feet wide and 10 feet deep. This will create approximately 16 acres of water surface and 225 acres of cattail marsh habitat for the endangered Yuma clapper rail and razorback sucker, and for a species of concern; the California black rail. Dredge spoil will be placed behind thick stands of saltcedar and phragmites that line the river's edge and in upland areas consisting primarily of saltcedar and arrowweed, or the dredge spoil will be discharged directly into the main river channel where it will eventually drift into the Imperial Dam's soil retention basin and be removed by dredging. Spoil may also be used to create beach areas or firebreaks. Dredge spoil will not be placed in wetland areas.

- Restore inflow and outflow to approximately 20 isolated backwater lakes adjacent to the river.

Several of the existing backwater lakes' inlets and outlets have been partially or totally plugged by silt and overgrown with phragmites, cane, or cattails. If flows are not restored, most of the lakes will become eutrophic within the next decade or sooner. Reclamation plans to open inlets and outlets with an amphibious excavator, 10-12 feet wide and 4-8 feet deep.

- Protect existing riparian stands of native cottonwood, willow, and mesquite.

Wildfires routinely destroy valuable habitats on the lower Colorado River. Because riparian habitat is so sparse on the river, and native trees rarely reach maturity due to the frequency of fires, some type of protection is necessary. There are approximately 125 acres of riparian habitat in the Imperial Division.

Reclamation plans to dredge around the perimeter of native tree stands, creating a water barrier fire break and also utilize dredge spoil as a firebreak. The newly created channel will provide an additional aquatic habitat. Protection of these native tree stands provides habitat for several song bird species, predatory birds, and the endangered southwestern willow flycatcher.

- Restore and enhance wetlands that have dried out in recent years due to lack of flows.

Flooding has scoured the river bottom lowering the water table directly adjacent to the river and silted in many of the historical wetlands. Succession of undesirable vegetation, because of lack of water, has replaced the wetlands' habitat with saltcedar, arrowweed, cane and phragmites.

Restoration and enhancement of several hundred acres of dried out habitat will benefit many species that exist in wetland ecosystems, especially the Yuma clapper rail, California black rail, and the razorback sucker.

The majority of the work will likely be accomplished with an amphibious excavator and dredge, but where feasible and economical, land based equipment may be utilized. Completion of the project would be spread over a 3-year period depending on factors such as funding, breakdowns, weather, river flows, bottom type, etc. Final work plans will be closely coordinated with appropriate agencies and other interested parties.

Associated with this project is an ongoing razorback sucker study to determine specific habitat requirements and further identify habitat management practices needed to recover the species from the threat of extinction. Reclamation is currently funding this research project being conducted by AGFD.

Reclamation will 50/50 cost share this work. To date Reclamation has no cost-sharing partners to accomplish this project but is optimistic that funding will be obtained in the near future, possibly through the MSCP. The end products of this effort will be the long-term restoration of river flows to wetlands and backwaters, improved water quality, and protection of riparian woodlands adjacent to the river. The project will improve biodiversity and productivity in the aquatic system at all levels, and reestablish public use.

7. Las Vegas Wash Wetland Restoration

Reclamation and NPS have entered into an agreement to construct two new wetlands totaling approximately 20 acres on the lower end of Las Vegas Wash near its discharge to Lake Mead. These two multi-purpose wetlands are designed to enhance marsh and riparian habitat within the eroded channel of the wash and also to provide for the polishing of perennial effluent flows. NPS has the compliance lead for this effort to enhance the habitat for the benefit of aquatic and riparian-dependent species.

8. Multi-Species Conservation Program Development

The lower Colorado River MSCP is a cooperative Federal-Lower basin States-Tribal-Private effort to conserve ESA-listed and sensitive species dependent on the river. DOI and the lower Division States have committed to cooperate and cost share (1:1 ratio) in the development of the MSCP, and the active participation of Native Americans, environmental and other interests are being encouraged. This program has the goal of benefitting more than 100 Federal- or State-listed, candidate and sensitive species and their habitats, ranging from aquatic, wetland and riparian, to upland. Additional information on this proposal is provided in Appendix A.

As part of the MSCP development process, Reclamation has dedicated resources to initiate the process and has agreed, along with other DOI agencies, to pursue additional resources, subject to Congressional authorization and allocations, to complete the cooperative development of the MSCP over the next 3 years. In this regard, Reclamation has provided funding for program development and interim conservation measures (see previous conservation discussion), as specified in the June 26, 1996, cooperative funding agreement(Appendix A). Reclamation's funding commitment for fiscal year 1996 is $300,000.

As proposed the MSCP will address Federal and non-Federal activities on the lower Colorado River for a 50-year period. Although the MSCP is envisioned as a single multi-party-sponsored program, ESA compliance for Federal and non-Federal actions will be conducted separately under the provisions of sections 7 and 10, respectively. Specific future Federal and non-Federal actions have not been quantified at this point, but will be since the final MSCP will require its own NEPA and ESA compliances. During the development of the MSCP and to meet its section 7 consultation obligations, Reclamation has provided this BA and requested formal section 7 consultation on its present discretionary routine operations and maintenance.

E. Summary of Secretary's Non-Discretionary and Discretionary Operation and Maintenance of the Lower Colorado River

1. Introduction

The preceding sections presented an overview of the complexity of the Secretary's management of the lower Colorado

River. His discretion and lack of discretion in managing the lower Colorado River are defined, as referenced several times, by the "Law of the River." As such, the Secretary, acting either directly or through Reclamation, is the Watermaster of the lower Colorado River basin. The following is a summary of the Secretary's discretionary and non-discretionary management activities on the lower Colorado River. The discretionary activities are those that are subject to the formal section 7 consultation initiated by this BA.

2. Non-discretionary

The Secretary has no meaningful discretion in the following activities:

a. Meeting water orders from entitled user in accordance with the AOP. [The Supreme Court Decree prohibits the Secretary from releasing water except for the expressed purposes and uses stated in the Court decree.]

b. Meeting the requirements of the Mexican Water Treaty (1.5 maf per year). [The Supreme Court Decree prohibits the Secretary from releasing water except for the expressed purposes and uses stated in the Court decree.]

c. Meeting flood control requirements.

3. Varying Degrees of Discretion

The Secretary has varying degrees of discretion, in some instances contractually burdened, on several operation and maintenance functions. Due to the complexity of the "Law of the River" regarding many of the following aspects, Reclamation has not gone to extraordinary detail to quantify which of a myriad of possible scenarios is discretionary or non-discretionary. Instead, the biological analysis contained in this BA assumes that the Secretary will abide by all existing contractual obligations and will not act unilaterally to void such arrangements. Additionally, the Secretary is obligated to fulfill the provisions of applicable Code of Federal Regulations (CFRs), several of which have been cited in this document. Without such presumptions, this document would lack an analytical framework from which to analyze either the Secretary's projected management actions on the lower Colorado River, or the biological effects of such actions.

However, in the event that the FWS determines that Reclamation's actions may cause jeopardy to a species and/or the adverse modification of critical habitat, Reclamation will work with FWS to determine whether any potential RPAs can be implemented consistent with the scope of the Secretary's legal authority and jurisdiction, along with the additional considerations set forth in 50 CFR 402.02. Also, the Secretary has the discretion to renegotiate contracts or reach voluntary agreements with contractual partners; and the Secretary has the discretion to initiate the review and revision of applicable CFRs.

a. The Secretary has very limited discretion regarding lower Colorado River water contracts. The discretion is essentially regulatory, i.e., assuring that each water entitlement contract holder does not exceed its entitlement amount. The Secretary has discretion in executing new contracts, limited to assuring that new users comply with the decree's requirements. The Secretary has the discretion to consult with the water entitlement contract holders to attempt to amend or renegotiate the contracts as exigencies occur. The Secretary can also consult with the water entitlement contract holders to achieve their voluntary accommodation of resource needs.

b. The Secretary is contractually encumbered by the terms of the Hoover and Parker-Davis electric service contracts and the repayment obligation for the $165 million advanced to the United States by non-Federal entities to up-rate the Hoover Powerplant. The Secretary has the discretion to consult with the electric service contractors to attempt to amend or renegotiate the contracts as exigencies occur. The Secretary can also consult with the electric service contractors to achieve their voluntary accommodation of resource needs.

c. The Secretary has discretion within some limits to manage the target elevations of Lake Mohave, Lake Havasu, and Senator Wash Reservoir. Such management flexibility is constrained by requirements to deliver entitlement and Mexican Treaty waters and to provide for system flood control. Senator Wash is currently restricted to a maximum surface elevation of 240 feet for safety purposes. However, it still provides a water regulation function which also benefits the introduced razorback sucker population and during this consultation will be operated to accomplish both. Reclamation does not stock non-native fish in these systems.

d. The Secretary has some discretion in making determinations of surplus, normal, and shortage conditions. Although the Secretary had the initial discretion to allocate unused apportionments in the river system's water supply, the lower basin States have exercised their right to such waters under the terms of the decree, contracts, and other obligations. It is anticipated that surplus declarations might be made and allocations of unused apportionments may be made available over the next 5 years. The Secretary may exercise some discretion by entering into additional contracts for surplus water or unused apportionment water contracts.

e. In order to assure water deliveries, the dredging of sediment upstream of Imperial Dam canal headings and the Laguna Settling Basin may be required within the next 5 years. The timing and method of such dredging is flexible under non-emergency situations.

4. Fully Discretionary

a. The Secretary has discretion in channel construction and maintenance as required by the CRFWLS Act. During the course of this consultation, Reclamation will not be constructing any new front work and levee system facilities and will only conduct minimum maintenance of existing facilities as needed on an emergency basis for the protection of such facilities and public safety. Such maintenance could use up to 80,000 cubic yards of rock and gravel per year. Reclamation's future quarry operations for river O&M will be addressed via separate biological assessments with the FWS.

b. The Secretary has full discretion to develop and implement plans to operate the YDP at one-third capacity for water marketing purposes. Additionally, the Secretary has discretion in how Reclamation maintains the 242 Well Field and other facilities in the 5-Mile Zone along the SIB. Reclamation does not plan to operate the YDP during the period of this consultation.

c. The Secretary has discretion in implementing ESA Section 7(a)(1) endangered species conservation measures. For example, the Secretary has exercised such discretion to date in the cooperative effort to preserve the endangered razorback sucker and bonytail populations in Lake Mohave and elsewhere on the lower Colorado River. These efforts include a number of rearing (breeding) facilities along the river.

d. The Secretary has discretion when making management decisions on actions that affect recreation, the natural environment, and private development (along with other activities). This discretion is limited by the fact that such decisions, involving such actions, do not result in a new or additional consumptive use of Colorado River water or violate other management mandates as specified in the "Law of the River."

III. ENVIRONMENTAL BASELINE

The environmental baseline for this assessment includes effects of past and ongoing human and natural factors leading to the current status of the species or its habitat and ecosystem (FWS 1994). Additional baseline information on hydrology and species abundance and distribution is provided in Sections II and IV, respectively.

A. Historic and Present Biological Communities on the Lower Colorado River

1. Introduction

Prior to development, the Colorado River flowed unimpeded some 1,700 miles with a vertical elevation drop of more than 14,000 feet from its beginnings in the southern Rocky Mountains and eastern Great Basin to its terminus at the Gulf of California (Ohmart et al. 1988). The lower portion of the river from the Grand Canyon downstream was typically low gradient and flowed through a rather broad alluvial valley with relatively few confined reaches. At its mouth was an alluvial delta containing vast marshes, riparian forests and backwaters. Such habitats were present along the entire reach of the lower river. At its mouth was an alluvial delta containing vast marshes, riparian forests and backwaters. Such habitats were present along the entire reach of the lower river. The riparian belt extended away from the river for up to several miles where the water table was relatively shallow.

Historically, the seasonal hydrograph and tremendous sediment loads associated with the lower Colorado River were dominating factors driving the physical and biological attributes of the ecosystem. Recorded flows at Yuma ranged from 18 cfs to 250,000 cfs with sediment loads averaging more than 10^8 metric tons per year (USGS 1973).

Seasonal flooding resulted in the creation of several distinct communities of plants and animals. High water occurred around June with low flows occurring during the winter months. Riparian communities were in a constant state of succession as the river, on a seasonal basis, was constantly depositing new sediment, shifting its channel, and creating and destroying habitat. Floodplain communities developed in areas that were seasonally, or only intermittently, inundated. Marsh communities developed in areas prone to extended periods of inundation, and the aquatic community evolved consisting of a main channel with separate or connected oxbows and backwaters.

The overall ecosystem of the lower Colorado River today is quite different from that which existed prior to modern day use and development. Table 4 summarizes the chronology of the lower Colorado River development which has, in part, resulted in the current ecosystem.

Table 4. Chronology of Lower Colorado River Development.

1700-1800	Exploration of lower Colorado River by Spanish priests and military, culminating with the establishment of a mission at Yuma in 1774 and its subsequent destruction by Yuma Indians in 1781 (Ohmart et al. 1988).
1848	Acquisition of lower Colorado River area north of the Gila River by the United States.
1840-1870	Exploration of lower Colorado River by U.S. military. Most of the early expeditions were exploring possible transportation routes through the area. Notes on the geology, flora, and fauna of the lower Colorado River were made. *Tamarisk* introduced into the United States as an ornamental tree and escaped cultivation by the late 1800s. Expansion of range rapid by the early 1900s, especially between 1935 and 1955 along the Colorado River (DeLoach 1989).
1850	Fort Yuma established by U.S. Army.
1852	First steamboat, the "Uncle Sam" captained by James Turnbull, travels up the Colorado River to re-supply Fort Yuma. Marks beginning of the steamboat trade which would eventually have profound effects on the mature riparian areas along the river (Lingenfelter 1978).

1854	Gadsden Purchase consummated, extending U.S. territory south of the Gila River to the present international boundary with Mexico.
1857	Lower Colorado River from Yuma, Arizona, north to present site of Hoover Dam explored by J.C. Ives; region reported to be valueless.
1862	Colorado River Gold Rush begins. 1861 silver strike at Eldorado Canyon and the 1861 gold strike at Laguna de la Paz created what is known as the Colorado River Gold Rush of 1862 (Lingenfelter 1978). Gold rush fueled steamboat trade along lower Colorado River. Initially, downed, dried cottonwood, willow, and mesquite were utilized as fuel for the steamboats (Ives 1861). Increased river traffic soon utilized all of the available wood debris, and crews began cutting down large quantities of cottonwoods, willows, and mesquites. By 1890, most of the large cottonwood-willow stands and mesquite bosques had been cut over (Ohmart et al. 1988; Grinnell 1914). Natural regeneration continued to establish new stands with each annual flood event.
1869	Colorado River from Green River in Utah to the Virgin River confluence explored by John Wesley Powell.
1877	Southern Pacific Railroad completes line over the Colorado River at Yuma. First diversion of water from lower Colorado River by European settlers for irrigating the Palo Verde Valley near Blythe, California.
1883	Second rail line crosses river. Together with the crossing at Yuma, the crossing at Needles by the Atlantic and Pacific Railroad in 1883 sounded the death knell of steamboat trade along the lower Colorado River (LaRue 1916). Declines in mining further reduced steamboat commerce, and by 1887, steamboats no longer went above Eldorado Canyon (Lingenfelter 1978).
1885	First documented improvements on the lower Colorado River. Lieutenant S.W. Roessler hired a barge and crew to make improvements at Six Mile Rapids and Mojave Crossing for navigation; first recorded instance of alteration of river (Smith 1972). Carp known established in the lower Colorado River ecosystem; first alteration of the native fish fauna (Minckley 1973).
1892	Channel catfish stocked into Colorado River by Arizona Game and Fish (LaRivers 1962)
1895	Construction begins on Alamo Canal at Yuma to irrigate Imperial Valley.
1901	Alamo (Imperial) Canal completed; water diverted near Yuma and conveyed through Mexico to irrigate the Imperial Valley in California; canal supplied 700 miles of lateral canals, enabling irrigation of 75,000 acres.
1902	Reclamation Act passed establishing U.S. Reclamation Service. U.S. government began planning large scale irrigation projects. (LaRue 1916).
1905	Flood on Gila River breaks through temporary diversion structure at Alamo Canal heading and Colorado River flows into Salton Sink.
1907	Southern Pacific Railroad repairs dike and redirects river back to correct channel. Salton Sea accidentally created from Colorado River floodwaters; 330,000 acres inundated; flooding increased the political pressure to dam the Colorado River.
1909	Laguna Diversion Dam completed; water diverted through the Yuma Main Canal to irrigate 53,000 acres in the Yuma Valley, Arizona, and 14,700 acres in the Reservation Division in California, and through the North Gila Canal to irrigate 3,500 acres in the Gila Valley, Arizona.
1910	Joseph Grinnell leads 3-month expedition from Needles to Yuma to collect data on mammals, birds, and associated habitats. Expedition provides one of first detailed accounts of the flora and fauna of the lower Colorado River. Grinnell observed carp and catfish, documented effects of Laguna Dam on the ecosystem, and documented loss of riparian habitat to agriculture (Grinnell 1914).

1913	Estimated acreage irrigated along the mainstem Colorado River between the Virgin River and the International Boundary was 367,000 acres, most of this being in the Imperial Valley (LaRue 1916). The 53,000 acres along the mainstem Colorado between Cottonwood Basin and the U.S./Mexico boundary resulted in a substantial loss of riparian habitat.
1920	*Tamarisk* appears along the mainstem of the Colorado River (Ohmart et al. 1988). This species is adapted to the changed riverine ecosystem and displaces native riparian species throughout the lower Colorado River. (Important wildlife habitats, including the cottonwood-willow gallery forests, have all but disappeared from the Colorado River and have been replaced by the less desirable *Tamarisk* [Anderson and Ohmart 1984b]).
1922	Colorado River Compact signed; water allocated between the upper (Colorado, Wyoming, New Mexico, Utah) and lower (California, Nevada, Arizona) basins.
1927	Irrigated acreage along the mainstem of the lower Colorado River increased from 53,000 in 1913 to 95,000 in 1927 (Wilbur and Ely 1948). Results in further decreases in riparian habitat.
1935	Boulder Dam (now Hoover Dam) completed; Lake Mead covers 300 square miles and stores 31 maf of water, enough to irrigate 650,000 acres in California and Arizona and 400,000 acres in Mexico. Hydrography of river changed; devastating floods eliminated. Hydropower of 4 billion kilowatt-hours produced annually. FWS stocks largemouth bass, bluegill sunfish, green sunfish and black crappie into Lake Mead; stock rainbow trout into river below Lake Mead (Jonez and Sumner 1954).
1938	Parker Dam completed; Lake Havasu behind dam covers 39 square miles and stores 600,000 acre-feet of water. MWD diversions into the Colorado River Aqueduct initiated. Imperial Dam completed; additional water diverted for irrigating southeast California and southwest Arizona. Pilot Knob Wasteway completed, allowing water diverted from behind Imperial Dam on the California side to be returned to the river.
1938-1939	Although largemouth bass and bluegills already present in the system, the State of California plants additional stocks to increase the spread of the species (Dill 1944).
1939	Gila Gravity Main Canal completed, replacing the North Gila Canal (from behind Laguna Dam) and delivering irrigation water from behind Imperial Dam to irrigate 105,000 acres in Arizona's Gila Valley.
1940	All-American Canal completed, replacing Alamo Canal and delivering irrigation water from behind Imperial Dam to Imperial Valley in California; 461,642 acres currently irrigated.
1941	Havasu National Wildlife Refuge established near Needles, California. Imperial National Wildlife Refuge established near Martinez Lake, Arizona. Siphon Drop completed, delivering irrigation water from All-American Canal to the Yuma Valley in Arizona; replaces Yuma Main Canal (sealed in 1948) originating behind Laguna Dam.
1944	Headgate Rock Dam completed; irrigation water diverted to the CRIT Reservation near Parker, Arizona; water diverted to enable irrigation of 107,588 acres.
1948	Coachella Canal completed; water from All-American Canal conveyed to Coachella Valley in California; 58,579 acres currently irrigated. Red shiners introduced to Colorado River as baitfish.

1950	Morelos Dam completed; irrigation water delivered by Mexico to the Mexicali Valley. Davis Dam closes and first water storage for Lake Mohave begins in January 1950. Powerplant still under construction.
1952	Yuma division stabilized from Laguna Dam to SIB; 17.6 miles of levees constructed, 17.4 miles dredged, 264,000 cubic yards of riprap placed, 41 miles of access roads constructed.
1953	Davis Dam and powerplant completed, providing regulation of water to be delivered to Mexico and regulating flows from Hoover Dam; Lake Mohave behind dam capable of storing 1.8 maf of water. Threadfin shad introduced into Lake Mead. By 1956, threadfin shad had spread throughout the lower Colorado River (Minckley 1973). Mohave Division from Davis Dam to Topock, Arizona, channelized and stabilized; 31 miles of channel dredged, 288,082 cubic yards of riprap placed, and 47 miles of levees built.
1954	Laguna Dam no longer used for diversion (Imperial Dam used instead).
1956	Topock Settling Basin completed, providing control of river sediment near Needles, California; 4,400,000 cubic yards of material excavated.
1957	Palo Verde Diversion Dam completed; irrigation water diverted to the Palo Verde Valley near Blythe, California; 121,000 acres currently irrigated.
1959	Striped bass introduced by the State of California into Colorado River near Blythe. (Introduced into Lake Havasu in 1960 and into Lake Mead in 1969). Became top fish predator in the Colorado River system.
1962	Flathead catfish introduced into river by State of Arizona.
1963-1967	Tilapia introduced into Colorado River by California and Arizona.
1964	Cibola National Wildlife Refuge established near Blythe, California.
1965	Laguna Settling Basin completed, providing control of river sediment north of Yuma, Arizona; 3,120,000 cubic yards of material excavated. Irrigated acreage estimated at 293,000 acres along the mainstem of the lower Colorado River (Lower Colorado Region State-Federal Interagency Group for the Pacific Southwest Interagency Committee 1971).
1966	Senator Wash Dam and Reservoir completed north of Yuma, reservoir covers 470 acres and holds 13,836 acre-feet of water. Topock Marsh inlet and outlet structures completed providing 4,000 acres of marsh habitat at Havasu National Wildlife Refuge.
1967	Palo Verde Oxbow inlet and outlet structures completed near Blythe, California, to provide wildlife habitat.
1968	River channel stabilized from Palo Verde Dam to Taylor Ferry; 19.5 miles. Banklines armored in Parker Division, Section I; 11 miles stabilized.
1969	Training structures south of Laughlin, Nevada, completed, reducing bankline erosion.

1970	Mittry Lake inlet structure completed south of Imperial Dam, to provide wildlife habitat. Cibola Division stabilized from Taylor Ferry to Adobe Ruin; 16 miles dredged.
1974	Cibola Lake inlet and outlet structures completed at Cibola National Wildlife Refuge, to improve wildlife habitat.
1983	Reservoirs on the entire lower river spilled for the first time due to extremely high precipitation from an El Niño weather event.
1985	Inlet structure to CAP aqueduct behind Parker Dam completed; water diverted to supply Phoenix and Tucson, Arizona; 0.5 maf currently diverted.
1992	Powerplant added to Headgate Rock Dam; maximum generating capacity is 19.5 megawatts (MW).
1993	Hoover Dam powerplant upgraded from 85 MW to 130 MW output.
1995	Parker Division, Section II stabilized.

2. Riparian Communities

a. Historic

Although the historic riparian communities along the lower Colorado River were dynamic, human-induced change since the beginning of the century has resulted in an ecosystem having significantly different physical and biological characteristics. Such changes have taken place as a result of the introduction of exotic plants (such as saltcedar), the construction of dams, river channel modification, the clearing of native vegetation for agriculture and fuel, fires, increasing soil salinity, the cessation of seasonal flooding, and lowered water tables. Figure 24 illustrates an example of the change in vegetation communities from 1879 to 1977.

The hydrology of the river created a series of terraces and bottoms along its route. Grinnell (1914) identified seven river associated communities. Five of these were specifically flood-plain in nature including: 1) Cottonwood-Willow association; 2) Arrowweed association; 3) Quail-bush association; 4) Mesquite association; and 5) Saltbush association. Two other communities, the River and Tule association, are also discussed (Ohmart et al. 1988). Figure 25 illustrates typical historic floodplain terraces and associated vegetation communities occurring along the lower Colorado River. Figure 26 illustrates a reconstruction of historic native plant community placement and principal species composition from original surveyor notes and plats along the lower Colorado River in 1879 [The General Land Office, now known as the Bureau of Land Management, initiated the original township surveys or cadastral mapping along the river in 1855. Not all the land was surveyed during the same period of time. Figure No.26 shows a reconstruction of the general vegetative types below Blythe, California in 1879 derived by interpreting floral descriptions contained in original field notebooks and then transferring these to the original field plats (Ohmart et. al., 1977 in Importance. Preservation and Management of Riparian Habitat: A Symposium, USDA Forest Service, General Technical Report RM-43)] .

The first terrace of the river was dominated by cottonwood (*Populus fremontii*) and Goodding willow (*Salix gooddingii*). Associated under-story shrubs were dominantly seepwillow (*Baccharis* sp.) (Ohmart et al. 1988); stands of cane (*Phragmites* sp.) were also common. Occasionally screwbean mesquite, although rare, was interspersed among willows in areas subject to infrequent flooding. Vegetation types found here were adapted to a frequently flooded environment, with their life-cycle often dependent upon flooding for successful regeneration. They tended to be short-lived and fast growing.

Seasonal floods resulted in the deposition of new sediment beds which served as nursery areas for new stands of cottonwoods and willows. Deposition of sediment was facilitated by plant growth which acted to slow water velocities across the floodplain. On other areas of the terrace, the floodplain was just as rapidly eroding away.

With respect to wildlife, the cottonwood-willow association was probably the most important biotically. Grinnell

(1914) noted 66 species of birds and 12 species of mammals, most of which were transient and migrant species. Grinnell noted that almost all of the birds listed for the willow association were either insectivorous or raptorial. Granivorous (grain eating) species were notably absent. The greater part of the passerine birds were transients or winter visitants. Only 3 were observed as permanent residents. The deer mouse (*Peromyscus maniculatus*) was the only observed rodent of wide and plentiful occurrence.

Three other rodents occurred locally, notably the cotton rat (*Sigmodon* sp). Otherwise, the only other mammals noted by Grinnell in the cottonwood-willow association were far-ranging predators. The paucity of terrestrial mammals in this association was probably due to the repressive effect of the annual overflow.

Arrowweed communities were found in a band along the outer margin of the cottonwood-willow communities where inundation was not as extreme. It typically produced an almost monotypic stand dense enough to preclude growth of other vegetation. Grinnell collected 14 bird and 6 mammal species here. The only bird that achieved noticeable abundance was the song sparrow (*Melospiza melodia*).

Honey mesquite (*Prosopsis glandulosa*) formed almost monotypic stands, with some associated undergrowth. The roots of honey mesquite are capable of reaching water tables up to 50 feet deep. Stands formed along the second terrace (see Figure 25) in areas that escaped flooding for a number of years, because the plant is intolerant of inundation. The second terrace typically occurred at an elevation of 4 to 18 feet above the river channel (Minckley and Brown 1982). This area was typically considered the outer edge of the riparian zone. More than 30 species of birds and 9 species of mammals were observed using this vegetative association, with mesquite providing both food and shelter (Grinnell 1914). Mesquite produced beans, which provided an important source of food for many species of wildlife, and served as a host for mistletoe which attracted insects and produced an abundant crop of berries. Several of the winter and resident birds of this association depended almost wholly on these berries (Grinnell 1914). Grinnell (1914) also observed 4 species of birds which bred in this association: Albert's Towhee, Crissal Thrasher, Lucy's Warbler, and Phainopepla. One mammal, the woodrat (*Neotoma albigula*), was commonly observed by Grinnell in the mesquite association.

The final riparian vegetative association was the saltbush or quail-bush association. It also formed almost monotypic stands or was associated in clumps with mesquite. Monotypic stands, when formed, tend to be clumped. As a whole, this area of the riparian zone was rather sparsely vegetated.

Creosote bush appeared quite often within this zone, although not achieving dominance until further away from the floodplain. Grinnell (1914) observed 13 species of birds and 3 species of mammals in this association. Although important for its food values, as seed production in this habitat type was abundant, additional values existed as escape and breeding cover for both birds and mammals. Quail and cottontail rabbits were often observed taking refuge in the tangled mass as did bush-inhabiting sparrows (Grinnell 1914).

b. Present

The system currently used to classify vegetation along the lower Colorado River is based on plant community and structural type (Anderson and Ohmart 1984). Six structural types have been described (I to VI) and refer to the proportion of foliage present in each of three vertical layers. For example, a plant community with structural type VI has most of its foliage in the lowermost layer, less foliage in the mid-height layer, and little or no foliage in the upper canopy. A structural type I community has well-developed foliage in all three layers, with the upper canopy dominating. Figure 27 illustrates the relationship between the six structural types and the foliage density at various heights. Community and structural types correlate with wildlife habitat quality, especially for birds; generally type VI provides the poorest habitat and type I the best.

Reclamation has mapped the distribution and acreage of the different riparian plant communities along the lower Colorado River since 1976 (Anderson and Ohmart, 1976; Anderson and Ohmart, 1984, Younker and Anderson, 1986). Updated maps, compiled from 1994 aerial photography, will be finalized in 1996. It must be stressed, however, that although the 1994 aerial photography covered the entire river from Davis Dam to the United States-Mexico border, the entire width of the floodplain was not flown in all places so that coverage is only approximately 80 percent of the previous efforts (John Carlson and David Salas, USBR, pers. comm.). Direct comparisons between previous acreages and 1994 acreages may not be applicable, especially for community and structural types prevalent at the extreme outer portions of the floodplain.

As of 1986, the lower Colorado River floodplain supported 107,749 acres of riparian, marsh, and desert vegetation between the United States-Mexico border and Davis Dam. This includes 45,037 acres of saltcedar; 5,754 acres of cottonwood-willow [Criteria used in classifying this community type (cottonwood-willow) included the presence of (Salix gooddingii) and (Populus fremontii) (the latter in extremely low densities) and where such species constitute at least 10 percent of total trees.] ; 1,683 acres of honey mesquite; 15,492 acres of screwbean mesquite; 7,880 acres of saltcedar and honey mesquite association; 8,930 acres of arrowweed; quail-bush and inkweed; 12,549 acres of marsh vegetation; and 426 acres of creosote scrub (Younker and Andersen 1986).

The most abundant community/structural types observed in 1986 (Younker and Andersen 1986) were, by far, saltcedar type IV (22,381 acres) and saltcedar type V (17,560 acres). Honey mesquite type IV consisted of 8,889 acres, saltcedar-screwbean mesquite type IV consisted of 7,825 acres, arrowweed type VI consisted of 7,478 acres, and quail-bush type VI consisted of 1,231 acres. A complete description of the 1986 community and structural type acreages found along the lower river (per River Division) is shown in Table 5.

Preliminary data from the 1994 flight shows a change in the acreage and structure of certain riparian plant communities (John Carlson and David Salas, USBR, pers. comm.). There is a net loss of approximately 2,300 acres of cottonwood-willow along the lower Colorado River below Davis Dam. This loss is almost entirely from the IV-VI structure classes which regenerated during the high flows of the early 1980s. Some of these young stands have survived and grown into structure type III stands while others were out competed by saltcedar. Contrastly, cottonwood willow types I-III have increased by over 1,300 acres below Davis Dam, with an additional 1,100 acres now present in the Lake Mead delta near Pierce Ferry, Arizona (Figure 28). This represents an over four fold increase in cottonwood-willow types I-III below the Grand Canyon. A similar trend may be observed in saltcedar structure types I-III. Riparian plant communities comprised of mesquite and/or saltcedar are difficult to compare between 1986 and 1994 because they are found throughout the floodplain and are especially prevalent at the outer extremes which the 1994 mapping effort did not adequately cover. A description of the 1994 data is shown in Table 6.

Since Grinnell's 1910 survey of the lower Colorado River, numerous additional surveys and investigations concerning the biotic attributes of the lower river system have been conducted. Probably one of the most recent and comprehensive terrestrial descriptions can be found in the Reclamation-funded *Wildlife Use and Densities Report of Birds and Mammals in the Lower Colorado River Valley* (Anderson and Ohmart 1977). This report describes the average densities and diversities of birds and mammals as associated with the 26 vegetative community and structural types mentioned above. The information given in this report was obtained from data collected over a 4-year period, and involved continuous year-round surveys in each of the habitat types from Davis Dam to the Mexican border, near Yuma, Arizona. Over 250 species of birds and approximately 15 species of mammals were observed during this survey. Generally, the survey showed the highest bird and mammal densities and diversities in cottonwood-willow with mesquite, mesquite-saltcedar (mix) and saltcedar communities, respectively lower. Thus, the diverse structural types I and II had the greatest species richness while the least diverse structure types V and VI had the lowest richness.

3. Marsh

a. Historic

With the exception of the lower Colorado River delta area, historic evidence suggests that backwater marshes that lasted several years seldom were very large along the lower Colorado River. Freeland (1973) stated that before completion of Parker and Imperial Dams, marshes along the river below Davis Dam were 1,000 acres or less in area. Grinnell (1914), as quoted in Ohmart et al. (1975), stated:

> "The river's habit of overflow would be expected to result in rather extensive tracts of palustrine flora. As a matter of fact, however, marshes were few and of small size. This was probably due to the rapid rate of evaporation of overflow water so that favoring conditions did not last long, and also to the rapid silting-in of such water basins as ox-bow cutoffs. As a result there were either almost lifeless alkali depressions, or lagoons practically identical in biotic features with the main river. But in a few places there were well-

defined palustrine tracts kept wet throughout the year, chiefly by seepage. These were always located back from the river near the outer edges of the broader valleys, where they were least affected during flood time. They were marked by growths of tules, sedge, and saltgrass, sometimes the latter alone, and were usually surrounded by arrowweed or willow associations."

Grinnell (1914) conducted a 3-month survey along the lower Colorado River. While the survey period was brief, and certainly couldn't include seasonal use of the river by the fauna, it is one of the few scientific biological surveys available to draw from for pre-development conditions of the river. Even by the time Grinnell conducted his survey, modification of the lower Colorado River had started. Diversions were in place north of Blythe, California, and at Laguna Dam, near Yuma, Arizona.

Observations by Grinnell in marsh communities (tule association) included 9 species of birds and 4 species of mammals. He noted that water birds, with the exception of herons, egrets, and bitterns, did not remain along the lower Colorado River to breed, and that the only mammal of abundance was the western harvest mouse. Other, less abundant, mammals included the hispid cotton rat, muskrat, and raccoons.

With regard to avian fauna, observations by Grinnell include only stragglers of white pelicans and the brown pelican was not seen at all. Cormorants were not seen until the party was in the vicinity of Laguna Dam, and they were seen only in small numbers. The blue heron was abundant along the whole course of the river from Needles to Yuma. The green heron was seen 5 miles above Laguna and was common from that point to Pilot Knob. The common egret was seen in only one place; the recently silted-in area above Laguna Dam. Fifty black-crowned night herons were seen in a pond below Ehrenberg; the species was also common farther down the river. Killdeer were scarce and the spotted sandpiper was occasionally sighted. The belted kingfisher occurred only as a migrant.

b. Present

Present-day marshes along the lower Colorado River are of two kinds. The first kind includes backwater marshes, which are defined as marsh areas adjacent to the river and which are either directly connected to the river or are connected by seepage. The second kind, which is more extensive, includes those marshes formed by impoundments such as the marshes in Mittry Lake, Imperial Reservoir, Lake Havasu, Topock Marsh, and other similar impounded areas.

The construction of river control features, such as training structures, along the lower ColoradoRiver has resulted in the formation of more permanent and expansive backwater marshes. There are over 400 backwater marshes along the lower Colorado River today from Davis Dam to Laguna Dam. Some of these marshes were created and are maintained specifically for mitigation for channel improvement projects. Reclamation actively pursues maintenance and restoration of backwater marshes not tied to mitigation on a cost shared basis. These backwater marsh habitats are subject to successional factors as were the historic marshes along the river. Under normal operating conditions, this succession is greatly slowed because current river conditions and operating criteria result in less scouring and associated sediment movement. Bankline stabilization has reduced erosion and associated sediment accrual to the river. When exceptional conditions are encountered, such as the high flow releases which occurred in 1983-1985, channel scouring occurs with associated sediment deposition in those backwater areas. These exceptional conditions would be expected to promote accelerated succession to upland conditions which are dominated by saltcedar (*Tamarix* sp.).

The majority of the banklines of the flowing river have been stabilized. This does not allow for natural marsh formation resulting from the river channel moving laterally, which would occur during high flows. Additionally, current river operating criteria reduce the opportunity for high flows (floods) which would also reduce natural marsh formation during those type of flows. A portion of the backwater marshes, which exist along the river today, are isolated from the main river channel, reducing the opportunity for flushing flows through them. However, it was observed during the high flows experienced on the river during 1983 through 1985, the isolated backwater marshes did not fill in with deposited sediment. Impacts which occurred to those isolated backwater marshes were a result of the main river channel scouring and the resulting drop in water table. In any case the marsh communities formed, as a result of the impoundments and training structures, are much greater in extent and permanence than those which occurred historically. As stated above, some of these marshes are specifically maintained for fish and wildlife purposes.

In 1986, the lower Colorado River floodplain supported over 12,000 acres of marsh associated habitat (Table 5). Younker and Anderson (1986) classified the marsh communities into six different types based primarily on the percentage of cattail, bulrush, common cane and open water (Table 7). Of the total 12,000+ acres of marsh habitat found, nearly 50 percent (5,657 acres) was classified as type 1 which met the criteria of being nearly 100 percent cattail/bulrush with small amounts of common cane and open water. For descriptions concerning the remaining amounts and type of marsh habitat observed by Younker and Andersen refer to Tables 5 and 7.

Table 7. Marsh types and criteria used in classification, lower Colorado River

Type	Criteria
1	Nearly 100 percent cattail/bulrush; small amounts of phragmites and open water
2	Nearly 75 percent cattail/bulrush; many trees and grasses interspersed
3	About 25 to 50 percent cattail/bulrush; some phragmites, open water, some trees, and grass
4	About 35 to 50 percent cattail/bulrush; many trees and grasses interspersed
5	About 50 to 75 percent cattail/bulrush; few trees and grasses interspersed
6	Nearly 100 percent phragmites, little open water
7	Open marsh (75 percent water); adjacent to sparse marsh vegetation; includes sandbars and mudflats when Colorado River is low

Vegetation mapping being completed in 1996 shows the lower Colorado River floodplain supporting a little over 11,000 acres of marsh habitat. Of this amount, 4,216 acres were classified as type 1, down about 25 percent from 1986. This was to be expected, as the high flows from 1983 through 1985 had created additional marsh area. Upon the return to normal flows, these areas reverted back to terrestrial.

In addition to 1986 type maps, Reclamation funded a 1986 report describing the development of a fish and wildlife classification system for backwaters found along the lower Colorado River from Davis Dam to Laguna Dam (Holden et al. 1986). The 2.5 year study effort resulted in over 400 backwater areas being identified and classified. The backwaters were characterized by State, distance from the SIB, river division, how formed (natural or man-made), quality of associated riparian vegetation, how accessible, size, how connected to the river, shape, permanence and actual acreage of open water.

After classifying the backwaters, seasonal field studies were then undertaken to sample fish and wildlife distribution, abundance, and preferences. Eighteen individual backwaters were sampled. These efforts included sampling water quality, zooplankton, benthic macro invertebrates, and fish in nine fishery study backwaters. Wildlife studies on the 18 backwaters also included morning bird censuses, night spotlighting, small mammal trapping, and aerial waterfowl surveys. Over 100 avian species, 25 mammal species and 15 fish species were observed, quantified, and associated with classified backwaters.

4. Aquatic

a. Historic

Historically, the lower Colorado River represented a unique aquatic habitat, ranging from a swift-flowing, turbid river during the annual runoff period (May-July) with flows exceeding 100,000 cfs to a gentle meandering river during late fall and winter periods with flows of 5,000 cfs or less (Grinnell 1914; Carothers and Minckley 1981). Remarkably high sediment loads accompanied floods and seasonal runoff from the Rocky Mountains. Sediment loads averaged more than 200 million metric tons per year during 1925 through 1935 leaving the Grand Canyon, but only 140 million metric tons made it as far as Yuma, Arizona. In all but those places where the river breached hard-rock barriers, the bottom continuously shifted as bedload was transported (Minckley 1979). Where the stream occupied broad alluvial valleys, sediment was deposited and wide, shallow, braided channels developed. As meanders matured, they were cut off to form oxbow lakes and backwaters. Extensive, although transitory, marshes were formed, only to be obliterated by vegetative succession, or more rapidly destroyed by currents and transported sediments during floods (Minckley

1979). Some of the larger historic backwaters and/or oxbows were persistent enough to be given names, these included Beaver Lake, Lake Su-ta-nah, Duck Lake, Spears Lake, Powell Slough (now part of Topock Marsh), and Lake Tapio. All were located between present day Bullhead City and Topock (Ohmart et al. 1975).

Along the lower river, changes in stage or water elevation were of two types. The first was the annual rise and fall due to flooding from snowmelt runoff. Because the river carried so much sediment, a film of silt clearly marked the annual high water level. Grinnell (1914) remarked on how tremendously high the silt line was up on the canyon walls in the more restricted reaches of the river. During floods, the wide valley sections, such as those near Blythe, California, and again at Cibola, Arizona, were flooded as the river overflowed its banks. Because of the great sediment loads, depressions were often filled in so that when the water receded, it left a relatively flat plain.

The second type of change to water surface elevation was at best unpredictable and was related to both the constant shifting of channels, as the river deposited sediments, and local storms. Grinnell (1914) states:

"The time of lowest water is in midwinter, that of highest flood in June....while throughout the year fluctuations of less extent are liable to occur at any time."

As an indication of just how rapid these flow changes were, Grinnell (1914) made the following statements in regards to trying to trap beavers:

> "Further troubles in our efforts to trap beavers resulted from continual rising or falling of the river and from the heavy deposit of silt.....At the last trapping place, the lowering of the water repeatedly exposed both the traps and stakes...."

Another indication of rapid water level changes is gleaned from Grinnell's (1914) observations on great blue herons during his 1910 surveys of the lower Colorado River:

> "Along the whole course of the river....blue herons were almost continually in sight. Their chief foraging grounds were the mud bars traversed by shallow diversions of the river. The habit of the river of having frequent periods of falling water, even when, as in the spring, the aggregate tendency is to rise, results in the stranding of many fishes in the shallow overflows as the water seeps away or evaporates. This frequently recurring supply of fish appears to be the chief source of food of all the species of herons occurring in the region."

Water temperatures fluctuated seasonally with the water being warmer in spring and summer and cooler during fall and winter. Physico-chemical regimes varied with the flow regimes; i.e., spring run off, summer flooding, or conversely, summer drought. Temperatures most likely resembled those today in reaches far from mainstream reservoirs. Nighttime water temperatures decline rapidly as a result of evaporation into dry air and respond quickly to intense insolation at sunrise. Daytime water temperatures were often 86°F in low-elevation, desert streams but approached104°F when insolation was accompanied by high relative humidities (Deacon and Minckley 1974). Chemical conditions, prior to closure of dams, must have been almost as highly variable as discharge. De-oxygenation of deeper parts of many backwater habitats occurs today and must have prevailed locally in the past. Total dissolved solids were high, especially during drought, and Sykes (1937) recorded a fish kill in the lower Colorado River as a result of an influx of "alkali" waters from the Gila River in the late 1800s.

Productivity in the main river channel was low, with the food-web being primarily detrital based (Minckley 1979). High turbidity limited the development of phytoplankton, and the shifting silt substrate inhibited development of benthic algal, macrophytes and invertebrate communities. Riverine organisms subsisted primarily on detrital drift from upstream or the surrounding riparian communities. Autotrophic production was limited to river margins or in backwaters, sloughs, and oxbows lateral to the main channel where sediments dropped out, allowing light to penetrate the water column. Grinnell (1914) credited main channel turbidity and sediment load for the lack of aquatic weeds along the lower river, and therefore the sparsity of waterfowl. He inferred the high importance of backwater sloughs to herons and fish was related to the lack of turbidity there:

> "For reasons already explained there is relatively little cryptogamic aquatic flora in the Colorado River.

> There is therefore little or no food-supply from this source to attract plant-eating ducks. This category of water-birds was, in fact, very sparsely represented. On the other hand, herons were notably plentiful because of the supply of catfish and carp made abundant at intervals by the drying-up of overflow ponds. While fishes were not abundant in the main stream, they were plentiful in backwater sloughs, where, the water was more nearly clear because the sediment had a chance to settle out." (Grinnell 1914)

Litter fall from the surrounding riparian zone was another important source of nutrients driving production in backwater areas (Minckley 1979). Fish often moved in and out of backwaters, where the sunlight and nutrients allowed for the development of invertebrate and plankton communities (Seethaler 1978, Vanicek 1967). These habitats served as nursery areas for many fish species.

The historic fish community of the lower Colorado River was de-depauperate (in a species richness sense), probably representing a combination of effects from the Pleistocene ice-age, tremendous environmental fluctuations, and complete isolation from other drainages (Miller 1959). The historic fauna had one of the highest levels of endemism of any river basin in North America (Miller 1959). There were 10 native species of fish in the lower river.

Three species were marine in origin (Minckley 1979). They include the spotted sleeper (*Eleoteris picta*) (only 1 specimen has ever been catalogued), the Pacific tenpounder (machete) (*Elops affinis*) (typically estuarine but does ascend into the lower reaches of many rivers), and the striped mullet (*Mugil cephalus*) (another estuarine species often found in the lower river, at times, in quite large numbers). None of these species' ranges extended much past the location of the current Imperial Dam (Minckley 1979).

Desert pupfish (*Cyprinodon macularius*) were found in the lower reaches of the Colorado and Gila Rivers into the early 1900s. These fish inhabited backwaters and springs lateral to the river margins (Minckley 1979). No known collections of this species were made in the Colorado River upstream of Yuma (Dill 1944).

Six other species historically occurred in the river: bonytail (*Gila elegans*), roundtail chub (*Gila robusta*), Colorado squawfish (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), flannelmouth sucker (*Catostomus latipinnis*), and woundfin (*Plagopterus argentissimus*) (Minckley 1979).

The roundtail chub probably occupied the lower river but was only collected sporadically. There were historical records from around Yuma, Arizona, but the fish were not believed to have been abundant (Minckley 1973). Roundtail chub typically inhabit smaller streams, such as the Salt, Verde and Virgin Rivers, and Moyle (1976) suggested that the fish captured around Yuma were rare stragglers from upstream tributaries. (Two roundtail chub captured above Imperial Dam in 1973 were described by Minckley [1979] as being heavily blotched in coloration typical of the populations of the Bill Williams River, an upstream tributary.)

Presence of the woundfin in the lower Colorado River may similarly reflect downstream displacement due to floods. Records indicate specimens of woundfin were collected near Yuma around the turn of the century, but no fish collections from the mainstem Colorado River have reported this species since. Today the species is limited in distribution to the Virgin River of Utah, Arizona, and Nevada (FWS 1995).

At one time flannelmouth suckers occurred in the entire lower river, but were very limited in numbers. Minckley (1973) suggests their distribution probably paralleled that of the razorback sucker and Colorado squawfish. The native population was most likely extirpated; however, a population of 600 was transplanted from the Paria River, a tributary to the Colorado River above Lake Mead, to the mainstem Colorado River below Lake Mohave by AGFD in 1976. That population has survived and exists today.

The remaining three fishes, Colorado squawfish, bonytail, and razorback sucker, made up the majority of the historical fish assemblage along the lower Colorado River. (The lower Gila River had a similar makeup of fishes.) Literature reviews suggest Colorado squawfish and razorback suckers were, at times, incredibly abundant, and bonytail were widespread and encountered frequently (Minckley 1979). However, probably owing to the dynamic nature of the river, wide fluctuations in reproductive success probably occurred. All three of these species are long lived and produce high numbers of young. These life-history factors allow for stability in the populations or at least persistence of adults when drought or other conditions do not allow for successful production and recruitment over a period of years.

Habitats used by these three fishes were variable. Body forms, such as dorsal keels on razorback suckers and narrow caudal peduncle on bonytail, were indicative of swift water habitats, but food availability was low in the main channel. Energy needs were high in swift water areas, especially during warm periods. Intuitively then, slack water areas such as oxbows, isolated channels, backwaters and flooded lowlands were important feeding areas for razorback sucker, bonytail,and Colorado squawfish. These habitats also provided refuges for protection, feeding, and growth of young fishes (Minckley 1979). During flooding, adults of all three species could avoid harsh current conditions by moving into these areas.

The migration habits of these fishes during predevelopment times are not known for certain, but can be hypothesized for at least Colorado squawfish and razorback sucker using data from recent studies (Tyus 1985; Bestgen 1990). (Data for bonytail are lacking.) Colorado squawfish in the Green River of Utah and Colorado have extensive spawning migrations (Tyus and McAda 1984) and must have had similar spring migrations for spawning in the lower Colorado River basin. Minckley (1979) proposed that there were fall migrations of Colorado squawfish to the lower river to feed on annual runs of striped mullets. This conclusion was based on the large numbers of Colorado squawfish reported in the lower river and the otherwise depauperate food supply. (Intuitively, a large number of predatory fishes could not be sustained unless adequate food resources were available.)

Razorback sucker are suspected of moving great distances to spawn, but field data are not definitive (Minckley et al. 1991). Data suggest that the fish are randomly dispersed prior to the spawning and move to spawning grounds but, at times, move also between spawning grounds (Minckley et al. 1991). Recent sonic tracking of razorback sucker in Lake Mohave show this same pattern. Adult fish were randomly distributed around the lake prior to spawning season and then migrated to spawning areas during January through March. Some of the tagged fish even visited two or more spawning aggregations during the same season, moving back and forth across the lake (G. Mueller and P. Marsh pers. comm.).

b. Development Along the Lower Colorado River

The present aquatic ecosystem of the lower Colorado River is tremendously different than that just described. These changes began in the late 1800s. The human populations of the Colorado River Basin States grew rapidly during the mid-to-late 1800s as people immigrated from the eastern United States and from other countries. Unfortunately for the native fishes of the American southwest, they did not come alone. The Colorado River basin, with its endemic fish community isolated for thousands of years, was invaded and swamped with new species in a very short period of time. Just as unfortunate for the native fishes, the growing human population set out to tame and harness the Colorado River, building flood control dams, storage reservoirs, and agricultural diversions. These two concurrent actions, introduction of non-native fishes and dam building, are described chronologically below.

The first fish "invader" was the common carp, *Cyprinus carpio*. Originally an Asiatic species, the carp reached California in August 1872, when a Mr. J.A. Poppe brought fish from Holstein, Germany, to Sonoma Valley. He raised them in ponds and sold the offspring in the western states, Hawaii, and Central America (Calhoun 1966). The species was stocked into Utah waters in 1881 (Sigler and Miller 1963), into Nevada waters in 1881 (Allan and Roden 1978), and into Arizona waters sometime prior to 1885 (Minckley 1973). The species was reported from the Colorado River basin before 1900 (Gilbert and Scofield 1898 *in* Minckley 1973). When and how the carp gained access to the Colorado River is not specifically known, but it most likely occurred in the 1880s. This was the period when the U.S. Fish Commission was championing carp as a table food. H.G. Parker, first Fish Commissioner for Nevada, stated in his 1881 biennial report, "One of my great aims has been to stock our waters with the best species of carp,..." (LaRivers 1962). Unfortunately, he attained his goal.

Channel catfish (*Ictalurus punctatus*) is the next documented exotic fish introduction for the lower Colorado River. Unlike the carp, this species is native to North America, commonly occurring in the Mississippi River drainage. The species was introduced into California in 1874 (Calhoun 1966) and into Utah in 1888 (Sigler and Miller 1963). The species was stocked into the lower Colorado River by the Arizona Fish Commission 1892 when 722 adult and yearling fish were released (Worth 1895 *in* LaRivers 1962).

The first large scale water diversion project for agricultural purposes on the lower Colorado River was the construction of the Alamo Canal. The Imperial Valley area around the Salton Sink was noted as a fertile valley with great agricultural potential back in the 1850s, but it needed water. A canal project was conceived then, but it didn't begin until 1895. The canal alignment was along the United States-Mexico border, and when constructed, much of the canal actually was in Mexico. The canal was completed in 1901, delivering water to Imperial Valley via diversion at Rockwood Gate. By 1904 more than 12,000 people had moved to the area and bought land for agricultural purposes through government auctions. However, the sediment load of the Colorado River was greatly underestimated, and by the end of 1904 the Alamo Canal was blocked with sediment and the Imperial Valley was again without water. To remedy this, a temporary diversion of the Colorado River was constructed at the United States-Mexico border. During a local flood which came down the Gila River in October 1905 this diversion failed and the entire flow of the Colorado River rushed into the Salton Sink. The break in the dike was repaired by the Southern Pacific Railroad Company in February 1907 (USBR 1981). Flowing of the entire Colorado River discharge into the Salton Sink for 16 months filled the Salton basin to an elevation of 195 feet **below** sea level. The Salton Sink which had been intermittently dry during most of the 19th century but had contained flood waters in 1828, 1840, 1852, 1859, 1862, 1867, and 1891 had not reached such a level for at least the last 300 years (Littlefield 1966). By 1925 the Salton Sea had dropped over 50 feet, to about -250 ft. msl.

The desert pupfish (*Cyprinodon macularius*) was most likely the only native fish in the Salton Sink prior to formation of the Salton Sea. (San Felipe Creek and Salt Creek, which were perennial, are suspected to have been occupied habitat.) Freshwater and marine fishes from the Colorado River entered the sink with the flood waters. A CFG information bulletin on the Salton Sea published in 1978 reported that the razorback sucker, bonytail chub, carp, and catfish were initial inhabitants, along with the striped mullet and the Pacific tenpounder (Hulquist et al. 1978). No mention was made of the Colorado squawfish, but it was most likely also present.

Being in a closed basin and located in a severe desert habitat help explain the rapid increase in salinity which occurred between 1907 and 1920. Initial solution of minerals from the floor of the Salton Sink, plus dissolved minerals in the agricultural runoff and drainage and the continuous evaporation of the surface water, combined to cause the salinity of the Salton Sea to increase to that of ocean water (35 parts per thousand) by 1920. Most of the fresh water fishes died off, leaving only the desert pupfish and striped mullet as abundant fishes. From 1929 to 1953 California introduced numerous sport fishes and other aquatic organisms into the Sea, including striped bass, silver salmon, halibut, anchovy and bonefish. All of these introductions failed except for the orange mouth corvina, sargo, and bairdiella, three marine species still present today. With salinity continuing to rise in the Salton Sea (now over 43 parts per thousand) it is speculated that sometime in the future the desert pupfish will again be the only fish inhabiting the Salton Sea.

Laguna Dam, located thirteen miles north of Yuma, Arizona, and roughly 8 miles upstream from the mouth of the Gila River, was the first structure to block the entire river channel on the lower Colorado River. Authorized in 1904 to provide diversion for the Fort Yuma Indian Reservation and the communities of Yuma, Arizona, and Bard, California, Laguna Dam was completed in 1909. The hydraulic height of the dam was only 10 feet (the difference in water surface elevation on upstream and downstream sides of dam). Dill (1944) described Laguna Dam as, "...passable to fish because of its low height and some breaks in it." Grinnell (1914) surveyed the flora and fauna around Laguna Dam in 1910, one year after it was completed, and made the following observations regarding Colorado squawfish:

> "A huge minnow (*Ptychocheilus lucius*), called locally "Colorado salmon," ...was plentiful immediately below Laguna dam, where many were being taken by the Indians living near there."

His remarks infer that Laguna Dam may have blocked passage of Colorado squawfish or at least provided a concentration point for their capture by local Indians.

Mosquitofish (*Gambusia affinis*) are native to the central United States and were widely introduced during the 1920s and 1930s for mosquito control. This species was introduced into California in 1922 and reported from the Salton Sea area between 1927 and 1929. The fish was widely spread along the lower river when Dill conducted his survey in 1942 (Dill 1944).

Largemouth bass (*Micropterus salmoides*) was the next exotic species to enter the Colorado River system. The species was stocked into California in 1874 (Calhoun 1966), into Utah in 1890 (Sigler and Miller 1963), and into Nevada waters by 1900 (LaRivers 1962), but it is unclear just when it was introduced into the lower Colorado River. Dill

(1944) mentioned the uncertainty of its origin, but inferred it predated Hoover Dam in the following statements:

> "The species has been planted several times in waters of the Colorado, and the existing stock undoubtedly has a multiple origin. Although present for many years, according to "old-timers," it did not become plentiful until the water cleared."

The "water cleared" with the closing of Hoover, Parker, and Imperial Dams in the late 1930s.

The Boulder Canyon Project Act of 1928 authorized two actions that forever altered the lower Colorado River. The first was the construction of Hoover Dam which occurred from 1931 to 1935. This was the first high dam on the river.

The most obvious change brought to the lower Colorado River by Hoover Dam was the trapping of the sediment by Lake Mead. Estimated to be as much as 200,000,000 metric tons annually, the sediment load of the river quickly dropped behind the massive structure. Lake Mead was expected to trap 137,000 acre-feet of sediment annually. As the reservoir filled, it was predominantly clear water, as most of the sediment dropped out in the lower reaches of Grand Canyon and in the rapidly forming delta at the head of the lake.

FWS (then the Bureau of Sport Fisheries) took advantage of these conditions by stocking game fishes including largemouth bass, bluegill sunfish (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and black crappie (*Pomoxis nigromaculatus*) into Lake Mead (Allan and Roden 1978). Lake Mead quickly gained national recognition as a great sport fishery when a 13 lb. 14 oz. largemouth bass won first place in the 1939 *Field and Stream* nationwide fishing contest (Wallis 1951).

At Hoover Dam the discharge was clear and cool. The river, freed from its sediment load because of the upstream reservoir, attacked the stream bed, removing sand and other fine sediments. This allowed for the introduction of another new sportfish, the rainbow trout (*Oncorhynchus mykiss*) FWS began stocking rainbow trout in 1935. Jonez and Sumner (1954) described the changing aquatic habitat and developing trout fishery in the Hoover Dam tailrace as follows:

> "Rainbow trout first were introduced below Hoover Dam in 1935. By 1937, the swift current below Hoover Dam had scoured the sand away from the gravel and rubble, leaving the water crystal-clear for a distance of about four miles below the dam. The first trout were being caught by 1940. By 1941, about 18 more miles of gravel and rubble had been scoured clean of sand. By 1947, the clear water extended about 42 miles below Hoover Dam....Between 1935 and 1951, a total of 3,714,054 rainbow trout was planted in the area which now is Lake Mohave."

The second action authorized by the Boulder Canyon Project Act of 1928 was the construction of the All-American Canal System which included the All-American Canal, Coachella Canal, and Imperial Dam and Desilting Works. Canal construction began in 1934 and was completed in 1940. Imperial Dam construction began in 1936 and was completed in 1938. Coachella Canal construction began in 1938 but was interrupted by World War II and was not completed until 1954.

Imperial Dam spanned the river just 5 miles upstream of Laguna Dam and formed the head works for two canals. On the California side, desilting works were constructed for the intakes of the All-American Canal, and the Arizona side contained the headgates and desilting works for the Gila Gravity Main Canal. These two canal systems have a design diversion capacity of over 17,000 cfs.

Unlike Hoover Dam and Lake Mead, Imperial Dam did not form a large, deep impoundment nor did it discharge clear water. However, it did cause considerable backing up of the water, and the formation of wide shallow lakes lateral to the main channel such as Ferguson Lake on the California side and Martinez Lake on the Arizona side. In these areas the water was clearer and quieter and good sport fisheries did develop.

In 1934, the same year construction began on Imperial Dam, work began on Parker Dam which formed Lake Havasu. Similar to Hoover Dam, Parker Dam blocked sediment flow, released clear water, blocked upstream and downstream migration of native fishes, became populated with numerous introduced fishes (both game and nongame) and generally continued the alteration of the historical aquatic ecosystem of the lower Colorado River. One feature associated with Parker Dam that was not heretofore seen along the lower Colorado River was the pumping plant constructed for MWD for its Colorado River Aqueduct. Accounts described in Dill (1944) suggested that the pumping plants removed large quantities of fish (albeit exotic) from Lake Havasu.

Headgate Rock Diversion Dam was completed in 1941 about 14 miles downstream of Parker Dam by the U.S. Indian Service to provide irrigation water to the CRIT Reservation near Parker, Arizona. This "run-of-the-river" structure has no real storage capacity.

Construction of Davis Dam in Pyramid Canyon some 67 miles downstream of Hoover Dam was begun in 1946 and completed in 1953. This formed Lake Mohave, a reregulation reservoir designed to meet the requirements of the Mexico Treaty of 1944.

Sometime between 1948 and 1953, red shiners (*Cyprinella lutrensis*) gained access to the lower Colorado River, probably as a baitfish release. It was being reared at that time as a bait fish at a private fish farm near the Colorado River in Ehrenberg, Arizona (McCall, 1980). NDOW and AGFD jointly stocked this species into Lake Mohave in 1955 (Allan and Roden 1978).

Threadfin shad (*Dorsoma petenense*) was introduced into Lake Mead in 1953 (Allan and Roden 1978), and into Lake Havasu in 1954 (Calhoun 1966) and quickly spread throughout the lower river system. Calhoun (1966) describes just how quickly this species took hold in the lower Colorado River basin:

> "Only two plantings, totaling 1,020 fish, were made in Lake Havasu. These threadfin and their off-spring populated the entire Colorado River from Davis Dam southward to the Mexican border, the Salton Sea, and related irrigation canals within 18 months."

As the threadfin shad became abundant, state game and fish agencies decided to make use of the new forage base by stocking another predatory fish, the striped bass (*Morone saxatilis*). Between 1959 and 1964, CFG made 19 separate stockings of this species between Davis and Imperial Dams, totaling over 100,000 fish. Most of these fish came from the Tracy Fish Screen near Stockton, California, at the intake to the Central Valley Project canal (Guisti and Milliron 1987). The species was stocked into Lake Mead in 1969 (Allan and Roden 1978).

The next nonnative fish introduction into the lower Colorado River was that of the African mouth brooder, the blue tilapia, *Tilapia aureau*. (A number of species of the genus *Tilapia* have been introduced and are not easily separated in the field. This group of fishes is herein referred to as "tilapia.") These fish were thought to feed on aquatic plants and were introduced for weed control in the irrigation systems. AGFD raised tilapia at its Bubbling Ponds facility near the Page Springs Hatchery and stocked these fish throughout the State between 1961 and 1980 (Grabowski et al. 1984). A breeding population of *Tilapia mossambica* was found in a smallpond near the Salton Sea in 1964 (St. Amant 1966 *in* Grabowski et al. 1984). CFG stocked Zilli's tilapia or redbelly tilapia into irrigation canals around Blythe, California, during the 1970s (Grabowski et al. 1984). Tilapia are common in the lower reaches of the river. No confirmed collections have occurred upstream of Parker Dam, although the fish is abundant in Alamo Reservoir on the Bill Williams River, a tributary to Lake Havasu.

Flathead catfish (*Pylodictis olivaris*) was first reported in Arizona from the Gila River basin in the 1950s (Minckley 1973). It was stocked into the lower Colorado River by AGFD in 1962 (McGinnis 1984). The species had spread upstream to Parker, Arizona by 1976 (Minckley 1979), and it was observed in Lake Havasu in 1984 (USBR file data).

The CAP began construction of intake facilities on the southeast end of Lake Havasu in 1973. The Havasu Pumping Plant lifts water over 800 feet to the start of a 335-mile long aqueduct. In full operation the Havasu Pumping Plant has a capacity of 3,000 cfs. The CAP will deliver an average of 1.5 maf of water each year to cities, Indian communities, industries and farmers.

c. Effects of Development and Present Day Aquatic Baseline

Today, the lower Colorado River downstream of Grand Canyon is a tremendously diverse aquatic ecosystem with over

240,000 surface-acres of open water (Table 8). There are over 27 fish species occupying habitats ranging from deep, clear reservoirs to turbid, flowing river, to warm shallow marshes. While the system on an overall basis is diverse, meaning one reach of river does not look like the next, individual reaches do not change much from season to season. The annual changes in the system are missing. Historically the river environment could be described in one word, **extreme**! The river annually went from hot to cold, and from raging flood to gentle tranquility. Today, reservoirs are clear and deep all year long. For example, over two-thirds the volume of Lake Mead remains at 55 degrees 12 months of the year, resulting in a constant, cool discharge at Hoover Dam. Even in the lower reaches of the Colorado River between Blythe, California, and Yuma, Arizona, where the river is turbid and shifting sand beds still occupy the river bottom, annual fluctuations in discharge and sediment load are almost immeasurable when put on a scale with the historical ranges of these parameters. Even the daily water level changes, which occur below almost every dam, are constant and rhythmic. Unlike conditions described by Grinnell (1914), whereby rapid changes in water levels trapped fish in shallow pools and side channels (to the benefit of herons), stranding of fishes under the current operational release patterns are extremely rare and virtually non-existent.

Table 8. Surface acreage of water along the lower Colorado River from Pierce Ferry to the U.S./Mexico International Boundary by river maintenance division (Water Classification).

DIVISION	FLOWING RIVER	RESERVOIR	BACKWATER	TOTAL
Lakes Mead & Mohave	0	191,500	20	191,520
Mohave	3,554	0	3,767	7,321
Topock Gorge	1,183	0	239	1,422
Havasu	515	20,510	740	21,765
Parker	3,748	0	1,364	5,112
Palo Verde	2,350	0	160	2,510
Cibola	1,971	0	505	2,476
Imperial	3,154	560	2,608	6,322
Laguna	436	25	585	1,046
Yuma	1,782	0	82	1,864
Limitrophe	0	0	146	146
TOTALS	18,693	212,595	10,216	241,504

The native fishes were adapted to the system of extremes. They spawned early, before the peak runoff, and their developing young moved into off-channel areas along with the rising flood waters to feed and grow. Migrations up or downstream were possible due to their body forms, and their long life allowed them to persist when reproductive failure occurred for successive years due to drought or other calamities. While top carnivores where included in the community, species such as the razorback sucker hid during the day and grew quickly to sizes less vulnerable to predation. The introduced fishes such as carp and catfish quickly invaded the off-channel habitats as witnessed by Grinnell (1914) who found them abundant in backwaters along with bonytail and razorback sucker. As discussed by Dill (1944), the physical extremes of the river system prior to dam construction must have been equally hard on native and nonnative fishes alike, and although these exotic fishes were present, their numbers were not great.

Dill (1944) reported that the populations of native fishes had declined prior to 1930. He proposed that native fishes were at a low point in their respective populations just prior to the period of dam building and that nonnative fish populations rapidly expanded with the taming of the river and prevented the rebuilding of native stocks. In his own words:

> "...it seems probable that the native fish populations have undergone alternate periods of rise and fall. But each period of destruction was followed by a period during which the population could rehabilitate itself.... Because of the unfavorable water conditions around the early thirties it seems possible that the population of native fishes sank to one of its low points and that the coincidental advent of clear water following Boulder Dam brought about a heavy production of bass and other alien fishes which preyed upon the already reduced natives."

Dill (1944) argued that the native fishes had a high biotic potential which had allowed them to bounce back from previous catastrophes and had it not been for the presence of exotic fishes, they would have done so.

Minckley (1979) similarly argues that dam construction alone was not sufficient to destroy the native fish communities of the lower Colorado River:

> "Destruction of the native fauna of the lower Colorado River has been attributed to physical modifications of the environment, such as channelization and construction of dams.... Considering the great age of the Colorado River, and correspondingly great ages of at least some of the genera of fishes inhabiting it...., sufficient time has been available for them to have experience far more change than has recently been effected by man.
>
> "Excluding special cases...., almost all declines in native fish populations are directly attributable to predation by small adults or juveniles of introduced kinds upon early life- history stages of indigenous forms. Shoreline and backwater habitats once exclusively available to non-piscivorous juveniles of suckers and minnows now are inhabited by mosquitofish and young centrachids, and cropping by those animals destroys the native fauna."

Clearly, destruction of the native fauna was not a one-time event. It took some time, and in the case of razorback sucker and possibly bonytail, it is still going on today. In Lakes Mead, Mohave, and Havasu native fish expanded their populations along with the expanding aquatic habitat as the water bodies filled. Jonez and Sumner (1954) described the spawning of both bonytail and razorback sucker in Lake Mohave and of razorback sucker in Lake Mead (detailed later in this volume in accounts of each species). LaRivers (1962) details spawning of razorback sucker in Lake Havasu in 1950.

One of the few observations made of large numbers of juvenile razorback sucker this century was made in Lake Mohave in 1950, and it serves here to demonstrate how these fish populated new reservoirs during initial filling. In describing the habitat used by razorback sucker, Sigler and Miller (1963) state the following:

> "This large sucker is an inhabitant of large rivers and has adjusted well to the impoundments of the lower Colorado River Basin.... The young occur in shallows at the river or reservoir margins where individuals approximately an inch long travel in schools numbering thousands. Over 6,000 specimens were taken in two hauls of a minnow seine at the margin of the Colorado River in Nevada on June 15, 1950. Here the temperature was 71-76 degrees F, whereas the adjacent river was only 58 degrees."

Davis Dam closed and began storage in January 1950. According to statements by Minckley et al. (1991), the above cited capture of juvenile razorback sucker occurred at Cottonwood Landing, which is approximately 21 miles upstream of Davis Dam. The quoted information suggests that the reservoir had backed up to that point, because the differences stated in water temperature between the riverine and ponded areas is similar to what is found today at the inflow of the Colorado River to the lake some 20 more miles upstream.

It seems apparent that as the new water bodies filled, native and nonnative fish were initially successful in recruiting young into adulthood. As time went on, the nonnative populations were able to prey on the eggs and young of native fishes and recruitment into adulthood all but ceased for the native fishes. Adults continued to survive until they succumbed to natural causes, which in the case of razorback sucker took upwards of 50 years.

Further data supporting the hypothesis that the native fishes were initially successful in recruitment were presented by McCarthy and Minckley (1987). They analyzed otoliths of seventy Lake Mohave adult razorback suckers killed between 1981 and 1983. Roughly 88 percent hatched prior to or coincident with construction and filling of Lake Mohave (1942-1954).

Ongoing work in the upper Colorado River basin, regarding the role of flooded bottom lands in the ecology of razorback suckers, provides just as striking information on how quickly the nonnative fishes can overshadow such recruitment. In attempts to increase natural recruitment of native fishes, FWS personnel flooded a bottom land parcel with water from the Green River, near Vernal, Utah, during the spring of 1995. At the end of the summer, they drained the wetland and found 28 young razorback suckers. These were the first young razorback suckers of this size observed in that age group since 1965. Unfortunately, they only represented a very small portion of the fish in the wetland. Of the 11 tons of fish measured, 95 percent were non-natives. Carp dominated the catch by weight, and fathead minnows (*Pimephales promelas*) were numerically the most abundant fish species (FWS 1995).

In the lower Colorado River of today, physical and chemical conditions do not favor the nonnative fishes over the native fishes, except for possibly lack of turbidity. Adequate water quality exists in the form of water volume, water temperature, dissolved oxygen, pH, specific conductance, hardness, etc. for reproduction, nursery, rearing/growth, and resting for native and nonnative fishes. Spawning habitat in the form of clean hard substrates are excessively abundant in both lentic and lotic reaches (relative to pre-Hoover Dam period). Primary production is adequate to sustain tons of fish production. Chlorophyl levels range from 1.0 to 5.0 mg/l (Paulson and Baker 1984), which is remarkably normal for fresh waters in the temperate zone world wide (Taylor et al. 1980). Zooplankton levels in mainstem reservoirs are on the order of 10 to 50 individual organisms per liter, a level typically found in temperate lakes across North America. Benthic invertebrates in riverine reaches are probably one or two orders of magnitude greater than that which occurred in the main channel Colorado River prior to Hoover Dam. Macrophytes abound in many reaches of the lower river, adding to the already high autotrophic production. So why do the native fish not survive?

The main problem is the sheer number of new species, all with reproductive potentials as great or greater than the native fishes. Taking the three most common native fish, (historically) razorback sucker has roughly 100,000 eggs per female, Colorado squawfish produce about 100,000 eggs per female, and bonytail produce roughly 50,000 eggs per female (Hammond pers. comm.). One of each species would yield 250,000 eggs per spawning season. Female carp average 500,000 eggs (Carlander 1969), striped bass in the lower Colorado River have over 500,000 eggs (Edwards 1974), one channel catfish produces 10,000 eggs (Carlander 1969), largemouth bass average 40,000 (Carlander 1977), one bluegill sunfish yield 25,000 eggs (Carlander 1977), one green sunfish produces 25,000 eggs (Carlander 1977), black crappie average 50,000 eggs (Carlander 1977), and even one four inch threadfin shad yields 10,000 eggs per year (Carlander 1969). One of each would total over one million for one year. Multiply these numbers by the factor of differential survival (e.g. catfish and sunfish guard their young in nests while the three native fish are broadcast spawners) and the picture becomes clearer. The nonnative fish quickly out produce the native fish. And while not all of these immature fish survive, the greatest number of each species present are the young fish (young of year and yearlings) which are the primary predators on young native fishes.

In Lake Mohave, Jonez and Sumner (1954) observed razorback sucker and bonytail (separate observations) spawning in large groups and the adults did not protect their eggs and larvae. In each observation, carp were observed feeding on the eggs, and young bass and/or sunfish were observed with the larvae.

Juvenile native fishes also succumb to predation. Marsh and Brooks (1989) report on the stocking of juvenile razorback suckers into the Gila River in Arizona between 1984 and 1986. They released 35,475 fish in three separate stockings. They concluded that channel catfish and flathead catfish within the first 40 kilometers of river downstream from the release sites were able to remove the entire population of planted fish.

One possible explanation for this high incidence of catfish predation was provided by the NFWG on Lake Mohave. Its work showed the juvenile razorback sucker to be nocturnal in habit, seeking protective cover during daylight hours. These observations suggest that juvenile suckers attempted to hide in the same cavities occupied by catfish, inadvertently seeking out the predator (USBR file data).

In summary, the aquatic ecosystem that exists in the lower Colorado River today, and forms the aquatic baseline for this BA, is highly modified and is physically, chemically, and biologically different than that which existed historically. Native fishes are mostly extirpated or endangered of becoming so. Physical modifications by dam construction and reservoir formation have homogenized the river system, effectively removing the "extremes" to which only the native fishes were adapted. Without such extremes the native fishes have no advantage over nonnative fishes and both groups are able to express their reproductive potential as regards to release of gametes. Differential mortality on native fishes due to predation on early life stages by nonnative fishes sufficiently suppresses the recruitment of native fish to the adult life stage and in a matter of only a few generations, extirpation is achieved. The primary limiting factor for recruitment of native fishes in the lower Colorado River basin today is nonnative fish predation on young life stages. This has been conclusively proven by the myriad of studies and experiments in which native fishes have been successfully reared in habitats from which nonnative fishes have been removed and excluded.

Recognizing this fact, a number of current conservation and recovery actions are being taken in the lower Colorado River basin by Reclamation and other agencies to raise native fish in protected, predator-free environments until they are big enough to avoid most predators occurring in the lower Colorado River. (These programs are described elsewhere in this document.) Similarly, fishery biologists in the upper Colorado River basin now recognize the problems caused by the invasion of nonnative fishes made possible because of dams and diversions and other developments along the Green and Colorado Rivers and their tributaries and are developing strategic plans to control nonnative fishes. Recent actions in the upper basin also include offsite rearing of native fishes and stocking of juveniles back into the river system.

B. Previous and Ongoing Section 7 Consultations

1. Colorado River Mainstem

Since 1973, Reclamation has informally and formally consulted under Section 7 of the ESA for various projects that potentially may have had direct or indirect effects on threatened and endangered species and critical habitat along the lower Colorado River (Table 9). Although the projects have varied substantially, as have the impacts, FWS has concluded that the projects would not jeopardize the continued existence of any species or its critical habitat. In some consultations, incidental take was provided by reasonable and prudent measures (RPMs). These consultations are considered as part of the environmental baseline in this document.

2. Baseline Projects

In addition to Reclamation activities that were evaluated for direct or indirect effects on the mainstream of the Colorado River, section 7 consultation and NEPA compliance have been completed or is in the process of being completed for authorized projects that provide facilities for the States to divert and distribute State waters confirmed by previously discussed court decrees. The CAP and Robert B. Griffith Water Project (southern Nevada) are summarized below as part of the environmental baseline.

a. Central Arizona Project Havasu Diversion

The CAP was constructed to provide a long-term, non-groundwater, water source for municipal, industrial, and non-Indian and Indian agricultural users in Arizona. The CAP was authorized for construction under the Colorado River Basin Project Act, Public Law 90-537 (82 Stat. 885), approved September 30, 1968. An approximately 330-mile long series of open canals, inverted siphons, pumping plants and tunnels convey water diverted from Lake Havasu on the Colorado River east through Phoenix and then south to the southern boundary of the San Xavier Indian Reservation southwest of Tucson. Under normally expected water supply conditions, project diversions from the Colorado River are expected to be about 1.5 maf per year of Arizona's basic annual entitlement of 2.8 maf.

Reclamation has consulted formally and informally on over 50 CAP-associated projects. In April of 1994, after 3 years of intensive formal consultation with Reclamation, FWS issued a final BO on the Transportation and Delivery of Central Arizona Water to the Gila River Basin (Hassayampa, Aqua Fria, Salt, Verde, San Pedro, middle and upper Gila Rivers, and associated tributaries) in Arizona and New Mexico. The opinion found that deliveries of CAP water would jeopardize the continued existence of the spikedace (*Meda fulgida*), loach minnow (*Tiaroga cobitis*), Gila topminnow (*Poeciliopsis occidentalis*), and razorback sucker and would adversely modify the critical habitat of the spikedace, loach minnow, and razorback sucker. Reclamation is now in the process of implementing the reasonable and prudent alternatives (RPAs) presented in the opinion. Reclamation's Phoenix Area Office is also preparing a biological assessment on the delivery of water into the Santa Cruz River Basin.

Table 9. Section 7 Consultations, Endangered Species Act, Lower Colorado River

Project Name	Species Involved	FWS Consultation Results	FWS Written Determination
Topock Marsh Dike Construction	Yuma clapper rail Peregrine falcon Bald eagle	"Non-jeopardy" with RPM's	09/13/84
Parker II Division Channel Modification	Bald eagle Yuma clapper rail	"Non-jeopardy" with RPM's	01/27/86
Mittry Lake Water Delivery System	Yuma clapper rail	"Non-jeopardy" with RPM's	10/29/87
Yuma Division Channel Modification and Levee Project	Yuma clapper rail Bald eagle	"Non-jeopardy" with RPM's	07/07/88
Nevada's Full Water Allocation	Desert tortoise	"Not likely to adversely affect"	02/21/92
Mittry Lake - Florida Largemouth bass Stocking	Yuma clapper rail Razorback sucker	"Will not likely affect"	05/07/92
Backwaters Dredging Restoration A-10	Bald eagle Yuma clapper rail Razorback sucker	"Will not likely affect"	05/08/92
Havasu Pumping Plant Recreation	Razorback sucker Yuma clapper rail Bald eagle Peregrine falcon	"No effect"	07/14/92
Backwaters Dredging Restoration C-10	Bald eagle Yuma clapper rail Razorback sucker	"Will not likely affect"	09/17/92
Parker II Channel Modification (Project continuation)	Razorback sucker	"Will not adversely affect"	08/09/94

Management of Lake Mohave Water Elevations	Bonytail Razorback sucker	"Not likely to adversely affect"	12/28/94
Hoover Dam Powerplant Uprating	Razorback sucker Bonytail Bald eagle Peregrine falcon Desert tortoise	"Not likely to adversely affect"	03/10/95
Southern Nevada Water Authority Treatment and Transmission Facility	Bonytail* Southwestern willow flycatcher* CA brown pelican* CA least tern* Bald eagle** Peregrine falcon** Razorback sucker** Mojave Desert tortoise***	* "No effect" ** "Not likely to adversely affect" *** "Likely to affect"	Informal 06/05/95; Formal consultation on tortoise due 9/3/96
Black Canyon Bridge Crossing (PROJECT CANCELED)	Peregrine falcon Bald eagle Bonytail Razorback sucker Desert tortoise	"May affect" Desert tortoise and Peregrine falcon; "Will not affect" other species	06/19/91
White amur stocking	Yuma clapper rail	"No effect"	05/09/90
Dredge RM 30.6 to 35.0	Yuma clapper rail	"No effect" [Biological assessment written in Environmental Assessment. Reclamation concludes No effect, with no negative comments by FWS after reviewing EA and FONSI]	04/18/84

Title I, A-22 Disposal Site	NONE	**NONE [Reclamation concluded in Environmental Assessment no endangered/threatened species in habited area.]	EA written 12/26/85
Havasu Division Dredging RM 217.6 - 218.5	Yuma clapper rail	"No effect" [Biological assessment written in Environmental Assessment. Reclamation concludes No effect, with no negative comments by FWS after reviewing EA and FONSI]	EA written 05/13/85
Bank Stabilization Parker II Critical Areas	Yuma clapper rail	Reclamation BA concluding No effect (NEPA = CE)	Letter to FWS 09/13/84
Senator Wash Reservoir Vegetation Removal	Yuma clapper rail	CE-50-85	1985
Mittry Lake Mitigation Title I	Yuma clapper rail	"No effect"	07/16/86
Nevada Levee Extension	No listed species		11/14/85
Dredge Imperial National Wildlife Refuge	Bald eagle Yuma clapper rail	"No effect" [Biological assessment written in Environmental Assessment. Reclamation concludes No effect, with no negative comments by FWS after reviewing EA and FONSI]	Provided
Three-Fingers Lake	FWS	FWS	FWS
Yuma Division Project	CANCELED	CANCELED	CANCELED
No Name Lake	Razorback sucker	"Not likely to adversely affect"	01/09/95
Irrigation facility Quechan Tribe	BIA	BIA	BIA
Quarries	Peregrine falcon Bald eagle Brown pelican Yuma clapper rail	"No effect" [Biological assessment written in Environmental Assessment. Reclamation concludes No effect, with no negative comments by FWS after reviewing EA and FONSI]	EA/FONSI 06/03/83
Backwater Restoration C-8	Bald eagle Yuma clapper rail Razorback sucker	"Not likely to adversely affect"	10/14/94

Backwater Restoration C-5 & A-7	Bald eagle Yuma clapper rail	"Not likely to adversely affect" [Biological assessment written in Environmental Assessment. Reclamation concludes No effect, with no negative comments by FWS after reviewing EA and FONSI]	EA 01/91
Quarries	Desert tortoise and others	Ongoing	
Maintenance activities/Irrigation facilities -Imperial & Riverside Counties CA	Desert pupfish	"No effect"	06/18/86
Imperial Division Enhancement Project	Razorback sucker & critical habitat	"May affect, not likely to adversely affect" - No adverse modification	11/21/95
Imperial Division Enhancement Project	Yuma clapper rail	"Not likely to adversely affect"	02/06/96
Spring Canyon Pumped Storage	Bald eagle Peregrine falcon Bonytail Humpback chub Colorado Squawfish Woundfin	"No effect"	04/16/87
Hoover Dam Spillway Modification	Peregrine falcon Bald eagle Bonytail Devil's Hole pupfish	"No effect"	02/27/85
Bullhead City and Lake Havasu City increased water allocations	Peregrine falcon Bald eagle Yuma clapper rail	"No effect"	Provided
All-American Canal Lining	Yuma Clapper rail Razorback sucker and critical habitat	"No effect on Lower Colorado River habitat or species"	02/08/96
Southern Nevada Water System Facilities Improvement Project	Mojave desert tortoise	"Non-jeopardy" w/RPM's	12/6/94

The Havasu Intake and Pumping Plant is located at the lower end of Lake Havasu downstream of the Bill Williams River Delta and within the Havasu National Wildlife Refuge.

The Havasu Pumping plant has the capacity to lift 2.2 maf per year of Colorado River water 800 vertical feet to the Hayden-Rhodes Aqueduct. Each of the six pump units has a capacity of 500 cfs. Trash racks with openings 6 x 16 inches cover the pump intakes, and predicted water velocity in front of the trash racks is 1.1 feet per second.

Reclamation's Havasu Intake EIS (January 1973) addressed native, rare, and endangered species, concluding that "...very few fish in comparison to the overall fish population on Lake Havasu will move through the intake channel and be adversely affected by pumping operations. These fish would be types oriented to open water movement and feeding, such as threadfin shad and striped bass." The EIS stated that there would be a monitoring program to assess losses of fish and other aquatic biota in Havasu and "...data obtained in this initial phase and subsequent phases will be evaluated to determine whether protective measures are required." The emphasis at that time was clearly on sport fishes. The Fish and Wildlife Coordination Act (FWCA) Report from FWS, dated June 30, 1976, also recommended studies to determine the extent of any fishery losses. At the time of the EIS and the FWCA report neither the bonytail nor the razorback sucker were on the endangered species list.

In 1989, FWS, AGFD, and Reclamation submitted their report on the Lake Havasu Fishery Study. Sampling was conducted on either side of a half-mile long dike that forms an enbayment leading to a cement-lined channel and the pumping plant. Seasonal sampling was conducted from the spring of 1984 to December 1985. No razorback suckers were found during this study. However, adult razorback suckers were observed in the CAP canal in 1986 (Mueller 1989). The potential effects of entrainment and diversion on this species is discussed in Section IV of this document.

b. Southern Nevada Water System (Robert B. Griffith Water Project)

An environmental assessment was prepared in 1992 to obtain a contract for the uncontracted remainder of Nevada's 300,000 acre-feet per year consumptive use apportionment. Section 7 compliance was concluded through informal consultation. By memorandum dated February 21, 1992, the FWS concurred with Reclamation's determination that the proposed action was not likely to adversely affect the threatened desert tortoise.

Improvements to the Southern Nevada Water System (SNWS) were identified in the 1994 Final Environmental Assessment of the Colorado River Commission's Proposed SNWS Facilities Improvement Project. The improvements are associated with existing facilities. As part of the environmental compliance, Reclamation entered into formal section 7 consultation with FWS on August 31, 1994, for the Mojave desert tortoise, a federally listed threatened species. On December 6, 1994, FWS rendered its BO that the SNWS Improvement Project is not likely to jeopardize the continued existence of the threatened Mojave population of the desert tortoise and no proposed critical habitat will be destroyed or adversely modified. Incidental take was issued with RPMs to minimize take.

A draft EIS for the proposed Southern Nevada Water Authority Treatment and Transmission Facility (SNWA-TTF) was provided for public review and comment in November 1995. A final EIS is expected by December 1996. Reclamation initiated formal consultation on the desert tortoise on August 15, 1995, and received a draft BO on December 18, 1995. Because of a number of project refinements, Reclamation requested a number of extensions to incorporate these changes into the final BO. The additional information and comments were provided to the FWS on June 26, 1996, and a final BO is expected by September 1996. The draft BO found that the proposed project is not likely to jeopardize the continued existence of the threatened Mojave population of the desert tortoise and no critical habitat will be destroyed or adversely modified. Incidental take was proposed with RPMs to minimize take.

3. Salton Sea and Endangered Desert Pupfish

During the public review of the draft BA, concerns were raised regarding the status of the endangered desert pupfish in the Salton Sea area. A summary of past ESA consultations is provided below.

Following listing of the desert pupfish as an endangered species in 1986, a BO was issued by FWS (June 18) on the effects of agricultural drain maintenance on this species. The opinion found that both agricultural drain maintenance activities by IID and CVWD and the introduction of sterile grass carp would not jeopardize the continued existence of desert pupfish. The opinion allowed for unlimited incidental take of the species during drain maintenance.

When the desert pupfish was listed as an endangered species (March 31, 1986), critical habitat was designated for the species along San Felipe Creek/San Sebastian Marsh, an intermittent stream and marsh complex on the west side of the Salton Sea. Reclamation purchased all of the private land holdings within the critical habitat area for $300,000 and turned this land over to CFG under a quitclaim deed in 1990.

In June 1992, a second BO was issued regarding drain maintenance and its affect on desert pupfish. The consultation involved the Salton Sea National Wildlife Refuge drains maintained by IID. The opinion again found that the drain maintenance would not jeopardize the desert pupfish; however only a limited incidental take was allowed due to recent observations of increased pupfish populations in the drains. This opinion also covered effects on Yuma clapper rails and California brown pelicans. Similar to the desert pupfish, FWS was of the opinion that drain maintenance would not jeopardize the continued existence of either species.

C. Non-Federal (Contemporaneous and Cumulative) Actions

The environmental baseline also includes State, local, and other human activities that are contemporaneous with the consultation in process, while cumulative actions involve future State or private activities, not involving Federal activities, that are reasonably certain to occur in the action area. The various categories of these non-Federal activities are summarized in Table 10, while the diversion and use of State waters by principal entitlement holders for 1993 are summarized in Table 11. A detailed accounting of lower Colorado River water diversions, returns, and consumptive use is provided in the "Calendar Year 1995 Compilation of Records in Accordance with Article V of the Decree of the Supreme Court of the United States in *Arizona* v. *California* Dated March 9, 1964" (Appendix I). It is anticipated that these contemporaneous non-Federal actions will continue in the future, and the potential effects of such actions are referenced for each ESA-protected species in Section IV. Additionally, these cumulative actions will be addressed in the MSCP process.

Many non-Federal activities (Tables 10 and 11), dealing with the direct use of mainstem water and resulting from the diversion of water from the mainstem, have affected or may affect the natural resources of the lower Colorado River and its extended environs. These can be classified as impacts occurring 1) on the mainstem river or its reservoirs, 2) on the river's floodplain, or 3) away from the river and its floodplain primarily due to the long-distance conveyance and use of Colorado River water.

In response to comments on the draft BA, Pilot Knob and Siphon Drop Powerplants are a special diversion feature of the All-American Canal that involves non-Federal power production and delivery of a portion of Mexico's Treaty water. The diversion essentially routes the water around the upper portion of the Yuma Division resulting in reduced flows in the river channel. The amount of water diverted depends on available canal capacity in the All-American Canal and the amount of Mexico's water order at any given time. The river in the Yuma Division is reduced in flow from Laguna Dam to the California wasteway (the outfall for water through the Siphon Drop Powerplant). At that point the river starts gaining water from Siphon Drop Powerplant to the Pilot Knob wasteway. The river again gains in flow at the Pilot Knob wasteway and is then diverted for Mexico's use at Morelos Dam. An expanded discussion of the operation of this diversion is found in Appendix D.

Table 10. List of non-Federal activities that affect or may affect the resources of the lower Colorado River and its extended environs.

	• diversion of state entitlement waters • potential decrease in water quality by: - municipal effluent discharge - storm water runoff - agricultural drainage - recreational waste

Affecting the mainstem river and its reservoirs	- other non-point discharges • trash accumulation • increased recreational use: - fishing - hunting - boating - swimming
Affecting the river's adjacent floodplain	• agricultural development: - land conversion - pesticide applications - soil erosion/minimum tillage - cropping patterns that benefit certain species - land fallowing • municipal and industrial development: - land conversion - air pollution (dust, automotive and industrial emissions) - natural area management • trash accumulation: - solid waste disposal (landfills) • increased wildfire frequency - reduced native riparian habitat/saltcedar expansion •increased recreational use: - hunting - camping - hiking - off-road vehicles
Affecting areas away from the lower Colorado River and its floodplain	• agricultural development: - land conversion - pesticide applications - water pollution (of ground or surface waters) - soil erosion/minimum tillage - land fallowing - air pollution (dust and smoke from burning field residues) - cropping patterns benefitting some species - water conservation and reuse • municipal and industrial development: - land conversion - air pollution (automotive and industrial emissions) - water pollution (of ground or surface waters) - solid waste disposal (landfills) - water conservation and reuse • increased recreation: - resource impacts (off-road vehicles, trampling) - management plans - developed recreational sites

Table 11. Amounts and uses of water diverted by principal water entitlement users in 1993.

Diversion Project	Irrigation Supply (acre-feet of water)	Acres Irrigated	Municipal and Industrial Supply (acre-feet of water)	Population Served
Ak-Chin Indian Community AZ	72,239	14,655		
Coachella Valley CA	304,174	58,579		
Imperial Valley CA	2,677,597	461,642	45,410	99,610
Cibola Valley AZ	22,184	3,557	37	199
Lake Havasu AZ			12,666	32,144
MWD			1,207,329	15,000,000
Arizona, miscellaneous	10,798	1,952	34,384	56,140
Mohave Valley AZ	37,741	4,186	6,394	12,050
Nevada, miscellaneous			31,455	7,000
Central Arizona Project	384,425	143,641		
Wellton-Mohawk (Gila Valley) AZ	291,817	56,814	876	1,605
Yuma Mesa (Gila Valley) AZ	316,743	33,360		
Southern Nevada Water Project			295,120	854,565
Palo Verde Irrigation District CA	219,780 [a]	121,000[a]		
Fort Mojave Indian Reservation CA, AZ, NV	129,767[a]	20,076[a]		
Quechan Indian Reservation CA	51,616[a]	7,743[a]		
Cocopah Indian Reservation AZ	9,707[a]	1,524[a]		
Chemehuevi Indian Reservation CA	11,340[a]	1,900[a]		
CRIT CA, AZ	717,148[a]	107,588[a]		
TOTAL	5,257,076	1,038,217	1,633,671	16,063,313

[a][Amount of entitlement; not necessarily amount actually diverted or irrigated.]